Hydraulics and Hydrologic Considerations in Planning Ecosystem Restoration Projects

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Jon Hendrickson
Hydraulic Engineer, St. Paul District
Regional Technical Specialist, Ecosystem Restoration, Mississippi Valley Division

Teaching Objectives

- Improve understanding of relationship between ecosystems and H&H
- Improve communication between biologist and engineers
- Understand H&H analysis needs for ecosystem restoration planning
- Conceptual Models

Ecosystem

American Heritage – an ecological community together with its physical environment, considered as a *unit*.

ER-1105-2-100 An ecosystem is the dynamic and interrelating complex of plant and animal communities and their associated nonliving environment, considered as an integrated unit. Implied within this definition is the concept of structure and function unified

Ecosystem Restoration

From ER 1105-2-100, Planning Guidance Notebook

Ecosystem restoration projects should be formulated in a systems context to improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating, functioning systems.

The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology.

Ultimately PDTs need to show that outputs are worth the costs

Annual Implementation Costs

Annual Ecosystem Output

Some Characteristics of Ecosystem Restoration Projects

- Could have a wide array of objectives and alternatives
- Cause and effect relationships not always clear
- Early stakeholder involvement, coordination with agencies
- Critical uncertainties: Invasive species, climate change, agricultural policies,……
- Models and methods vary from quantitative to qualitative

List of Project Types and Programs Identified at 9/17-18/08 Ecosystem Planning Model Requirements Workshop, Chicago, IL (ERDC, Divisions, Districts)

Table 1. Examples of the Range of District Planning Projects

- Freshwater wetland restoration
  - Island restoration
  - SAV restoration
  - Water Level restoration
- River/Stream restoration
  - Dam removal
  - Fish ladders
  - Emergent sandbar habitat creation
  - Floodplain restoration
  - Cottonwood forest restoration
  - River flow restoration

- Estuarine ecosystem restoration
  - Benthic habitat restoration
  - SAV restoration
  - Oyster habitat restoration
  - Salt marsh restoration
- Acid mine drainage
- Upland restoration
- Shoreline restoration/stabilization
- Lake/littoral marsh restoration

Early Communication

H&H Interaction within the Planning Team is important throughout project stages

- PDT members (especially Ecologists, Biologists & H&H) need to understand each others lingo and communicate early so that:
  - The correct questions are asked
  - The correct problems are studied
  - Objectives are established, clarified, improved, re-clarified,.....
  - Criteria for achieving objectives is established
  - Monitoring and modeling can be initiated early enough to explore unknowns

Single Step

H&H Communication Beyond the In-house Team

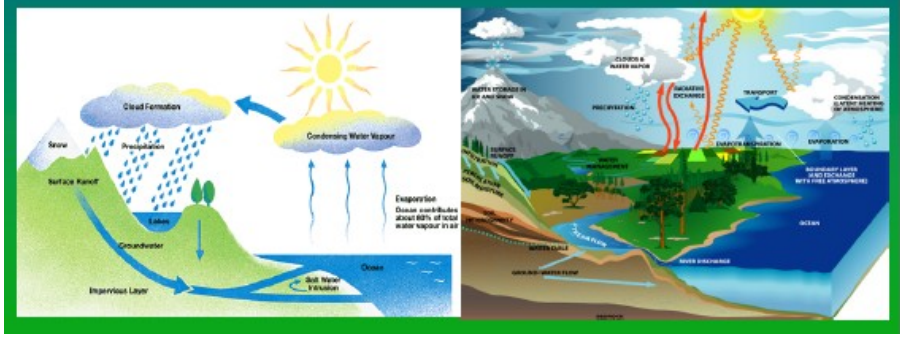
- Natural Resource Agencies
  - Local sponsor
    - O&M, Project Function, Project Stability
  - Water quality permits
    - Dredge material stability
  - State floodplain regulations
  - Refuge compatibility
  - Endangered species
- Public
  - Public meetings
- Watershed Districts
- NGOs

ut don’t forget to communicate with
e backhoe operator. If it can’t be built,
doesn’t matter how good your
ommunication was in the meeting room.

Conceptual Models (CMs) can be used to sort it all out and communicate

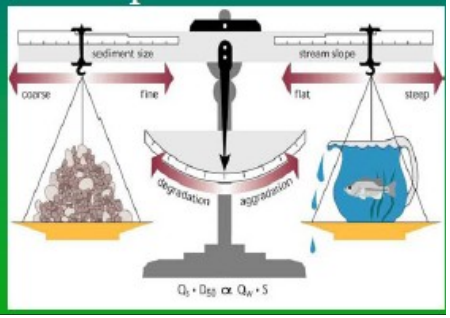
What Are Conceptual Models?

A conceptual model is a tentative description of a system or sub-system that serves as a basis for intellectual organization.



How are Conceptual Models Used?

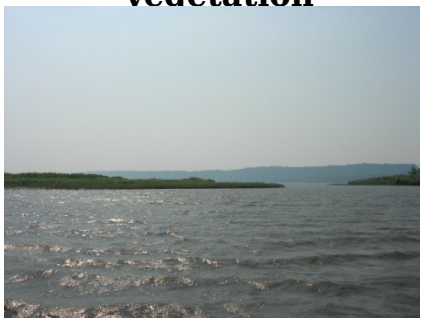
- Means of Organization and Communication
- Facilitate Detailed Analyses
- Metrics, Monitoring and Adaptive Management



Images from Webinar on Conceptual Models (Dr. Craig Fischenich,
ERDC, 1/27/09) Civil Works Environment Gateway
http://cw-environment.usace.army.mil/learning.cfm?

Minnesota Department of Natural Resources Conceptual Model for Water Level Management

High turbidity, poor vegetation



Increase vegetation using summer water level drawdowns to expose sediment and germinate plants

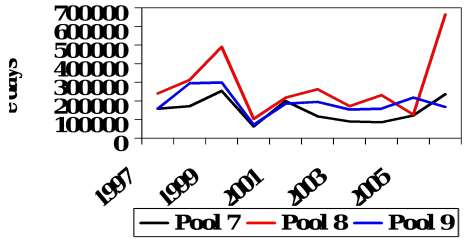
Sediments dry & oxidize, dormant seeds germinate, plants emerge .....

Vegetation collects sediments and improves water clarity ....

Clear water helps vegetation persist ...

Swans eat vegetation ...

Swans numbers increase



Bird watchers vacation near swans

Tourism $$ increase

An Ecosystem Conceptual Model based on Essential Ecosystem Characteristics (Harwell, et al., 1999) can be used to illustrate ecological relationships. he 5 EECs are shown below along with a few ecosystem restorat parameters categorized under the EEC.

Physical & Chemical Processes

Geomorphology
Sediment load
Erosion & Deposition
Delta formation
Sinuosity

Water Quality
Temperature
Dissolved Oxygen
TSS
Nutrients

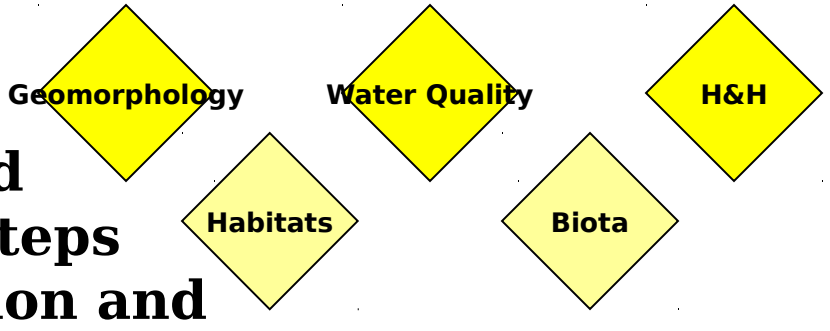
H&H
Wsel
Flow distribution
Waves
Duration
Groundwater
Velocity

Habitat & Biota

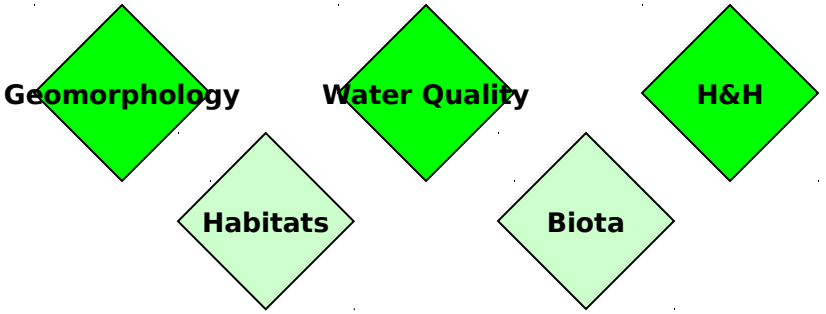
Habitats
Wetlands
Shallow water habitat
Connectivity

Biota
SAV (acres, composition)
Fish
Birds
Invasives

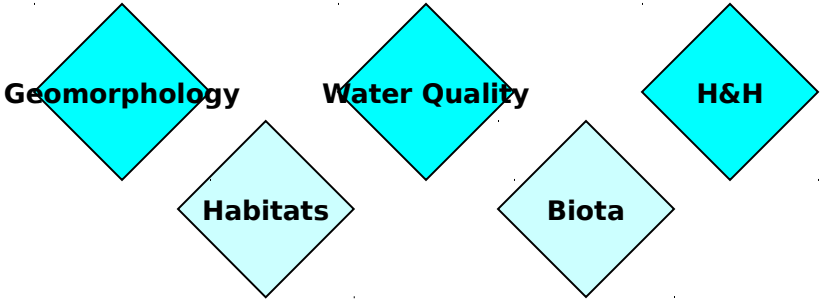
The EECs can be used in various planning steps to organize information and to identify monitoring and modeling needs and develop alternatives



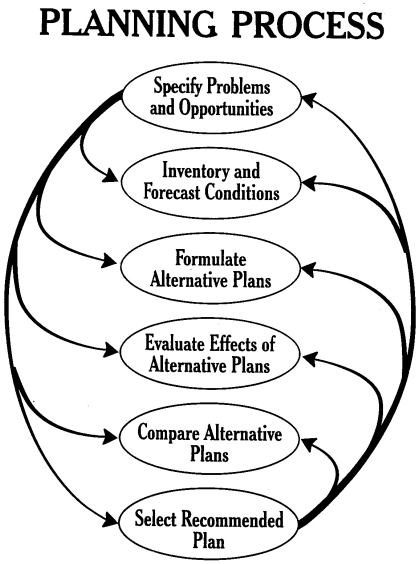
Problems & Opportunities



Existing & Future Conditions



Objectives & Constraints



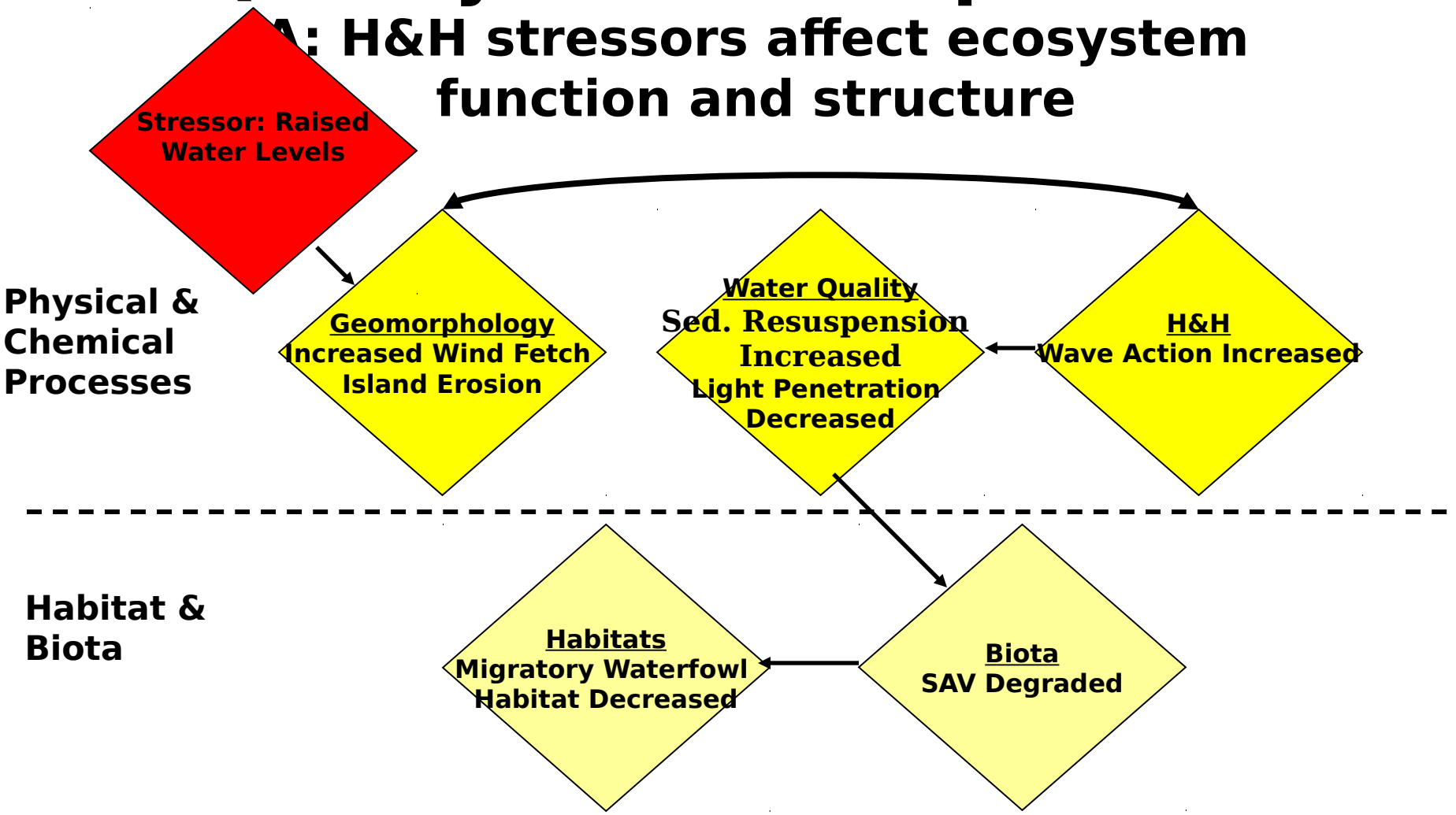
Monitoring Needs?
Modeling Needs?
Alternatives?

A tabular version of the conceptual model based on Essential Ecosystem Characteristics (EECs) could be used to organize information for the planning steps

	Biota	Habitat (Landscape)	Water Quality	Geomor-phology	H&H
Problems & Opportunities					
Existing & Future Conditions					
Objectives & Constraints					
Monitoring Need **Modeling Need** **Alternatives**					

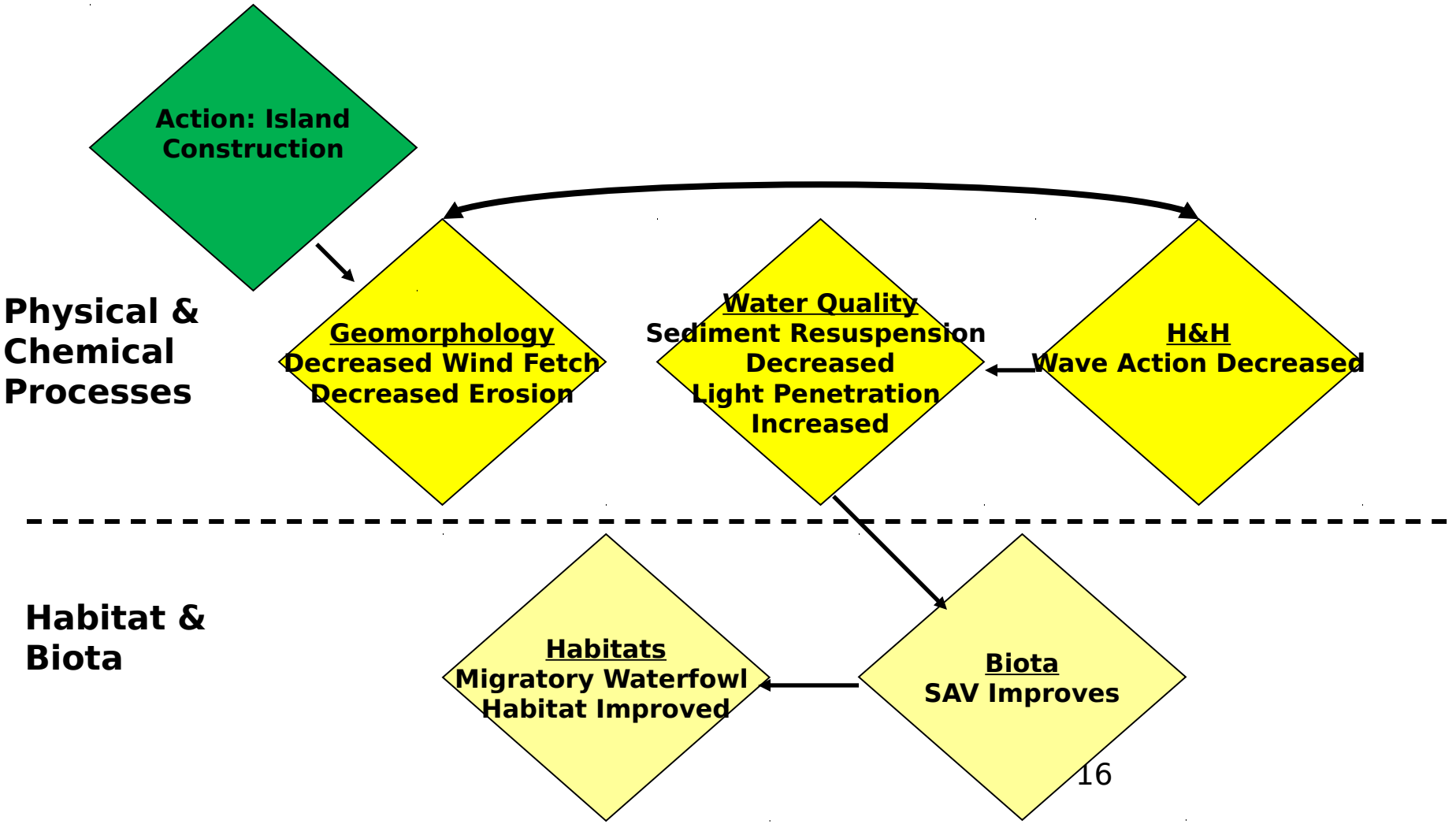
Q: Why is H&H Important?

A: H&H stressors affect ecosystem function and structure

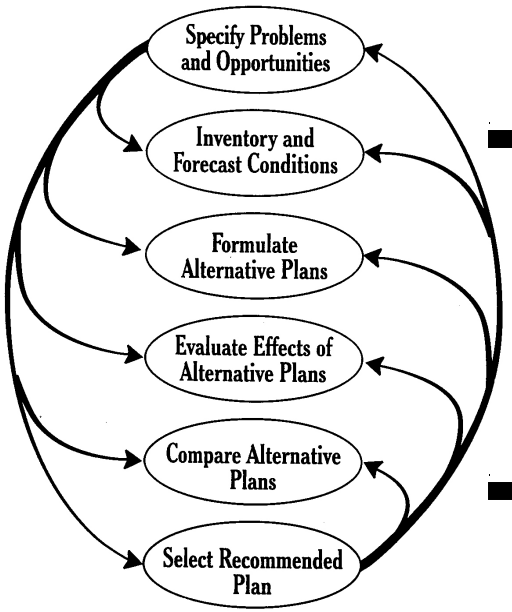


Q: Why is H&H Important?

A: Restoring ecosystem function and structure usually involves actions to alter H&H



PDT Tasks Associated with Planning, Design, and Construction



Define Functional, Structural, and Habitat Attributes for:

Existing Conditions
Future Conditions (ie. Future, no action)

Define Problems and opportunities
Define Objectives and constraints

Identify Management Measures

Formulate Alternative Plans

Evaluate, Compare, Alternative plans ↔ **Preliminary Design**

Cost Benefit (output) Analysis

Selection of Ecosystem Restoration Plan

Plans and Specs
Value Engineering

Contracting
Acquisition Strategy

Construction or Implementation

H&H Input

Modeling

Monitoring Needs

Feature Design

Impacts

Research

Lessons Learned

ceptual Model describing H&H input to planning

I models, monitoring, design, and knowledge
t support decision making during planning, but
highly structured, often time constrained
ework that can challenge interaction with
eam.

Some H&H Tools Supporting the Planning Process

- Hydraulic Design Information
- Analytical methods
  - Based on simplified hydraulic relationships for flow and sediment tranpsort
- Models
  - Also based on simplified (though rapidly repeated) hydraulic relationships
- Monitoring

Hydraulic Design Information

- Hydraulic Design Criteria

http://chl.erdc.usace.army.mil/hdc

- Engineering Manuals

http://140.194.76.129/publications/eng-regs/

- Handbooks

http://www.mvr.usace.army.mil/EMP/designhandbook.htm

- Lessons Learned
- Technical papers (ERDC, journals,…)

http://libweb.erdc.usace.army.mil/uhtbin/cgisirsi/nB2qK0lOnO/ERDC_VBG/157250018/60/502/X

Analytical Methods

$$Q = vA$$

$$Q = 1.49AR^{2/3}s^{1/2}/n$$

$$Q \cdot s \propto Q_s \cdot d_{50}$$

$$T = f\rho v^2/2$$

$$F = v/\sqrt{gy}$$

Where:

Q=Discharge

v=Velocity

A=Cross-sectional Area

R = Hydraulic Radius

s = Hydraulic Slope

n = roughness

Q_s = Sediment Discharge

d_{50} = sediment grain size

T = Shear stress

f = friction factor

ρ = density of water

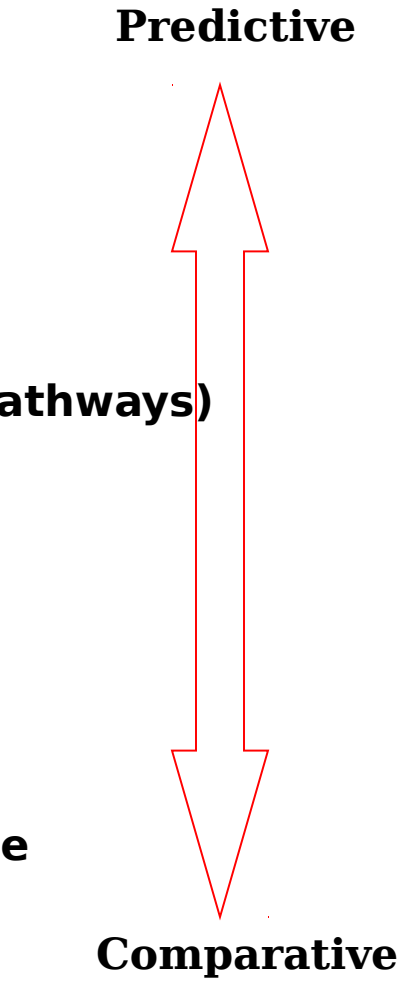
F = Froude Number

g = acceleration of gravity

y= water depth

Models: Simplifications of the Natural World

- **H&H**
  - **Steady/Unsteady Flow**
  - **1D, 2D, 3D**
  - **Channel scale, Watershed scale**
- **Geomorphology**
  - **Sediment Transport (Sources, Sinks, and Pathways)**
  - **Sediment Budgets, multiple grain size**
  - **River Meandering**
- **Water Quality**
  - **Constituent Transport**
  - **Temperature, D.O.**
- **Habitat**
  - **Life Stages, Life Requisites**
- **Biota**
  - **Aquatic and Terrestrial vegetation response**



Models Identified at 17-18 September 08 Ecosystem Planning Model Requirements Workshop

Table 2. Examples of the Range of Ecological Planning Models Used by Districts

- Wetlands Evaluation Technique (WET)
- Habitat Suitability Index (HSI)
- Ecological Diagnosis & Treatment (EDT)
- Hydrogeomorphic Model (HGM)
- Shared Vision Model (SVM)
- Forest Vegetation Simulator (FVS)
- Incremental Instream Flow Methodology (IFIM with PHABSIM)
- Habitat Evaluation Procedure (HEP)
- SALMOD
- FRAGSTATS (habitat fragmentation)
- Ecological Functions Model
- EPA Rapid Bioassessment Procedure (RBP)
- Wildlife Habitat Appraisal Guidelines (WHAG)
- Habitat Evaluation and Assessment Tool (HEAT)
- Vegetation Succession Models (SAV, CASM)

- HEC-1
- UNET
- HEC-RAS
- CE-QUAL-W2/RIV
- CE-QUAL-W2/RES
- Regional Simulation Model
- MODFLOW (family of models)
- WASH123D
- RMA
- SEAWAT
- EFDC
- Adaptive Hydraulics (ADH) sediment transport model
- Everglades Landscape Model (ELM)
- Quantitative Habitat Evaluation Index (QHEI)
- Fish Bioenergetics 3.0
- Benthic Index of Biotic Integrity (BIBI)
- Fish Index of Biotic Integrity (IBI)
- Floodplain Ecological Response (FER)
- Unified Stream Assessment Model
- Stella, Vensim, Powersim, Extend

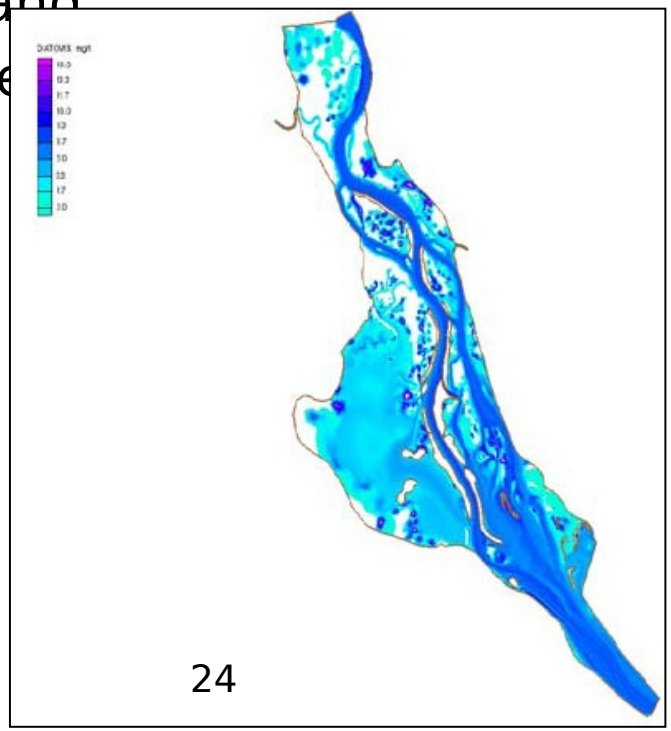
Model Depots

- System Wide Water Resources Program http://swwrp.usace.army.mil
- Hydrologic Engineering Center http://www.hec.usace.army.mil/
- Ecosystem Restoration Gateway

http://cw-environment.usace.army.mil/tools.cfm?CoP=Restore

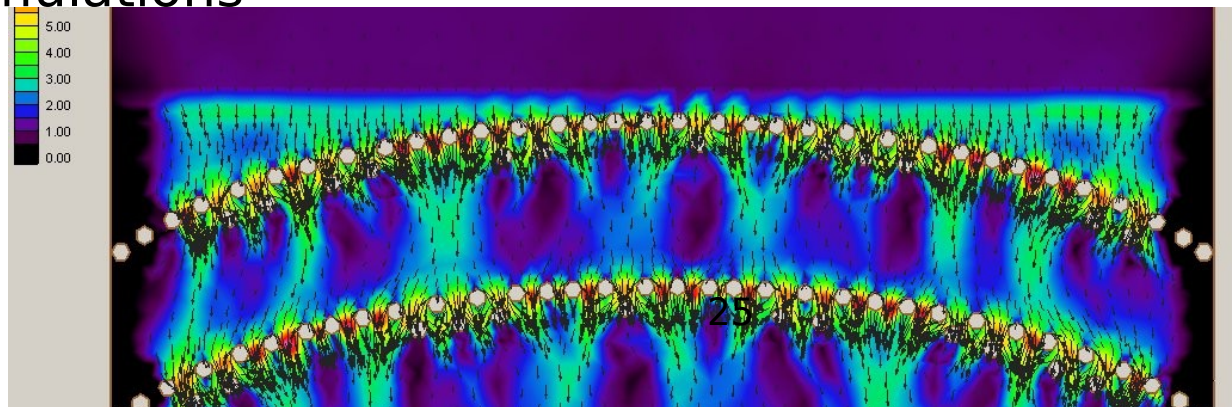
ADH-CASM

- CASM stands for the Comprehensive Aquatic Systems Model
- Has been used to look at alternatives in Pool 5 UMRS and for Mississippi River Gulf Outlet freshwater diversions
- Calculates daily changes in biomass and water quality
- In Pool 5, at each node, model depth and velocity is provided to aquatic food we algorithms.
  - Predicts Vallisneria Growth
- CASM Uses in USACE Planning
  - Baseline Conditions
  - Future Without
  - Alternatives
  - Implications of variability



ADH-ELAM

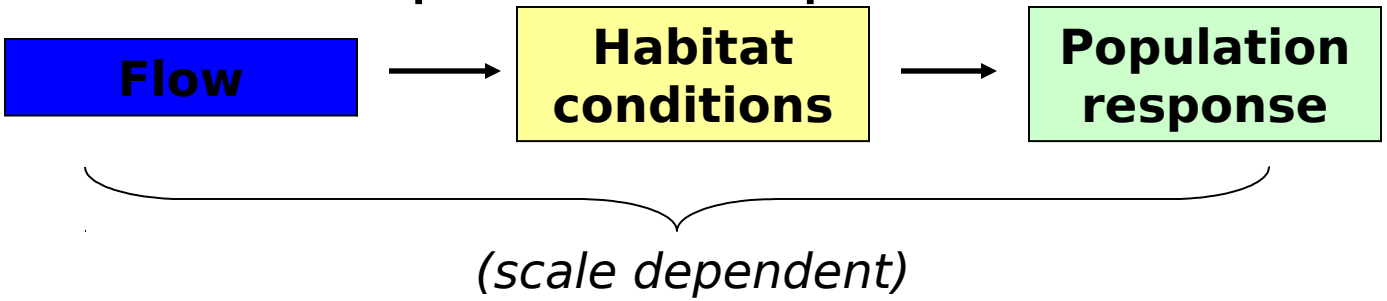
- ELAM (Eularian Lagrangian Agent Method)
- Being used to look at Fish Passage alternatives on the UMRS
- Was developed in the Pacific Northwest for Salmon projects
- Forecasts responses of highly mobile aquatic biota
- Limited by knowledge of fish response to hydraulic stimulus
- ELAMs offer a way to more closely couple ecosystem response to physical conditions
- ADH model describing flow field was used for Lock and Dam 22 Fish Passage simulations



HydroMussel:

Flow-based Ecological Modeling Software

ADH User Group Workshop



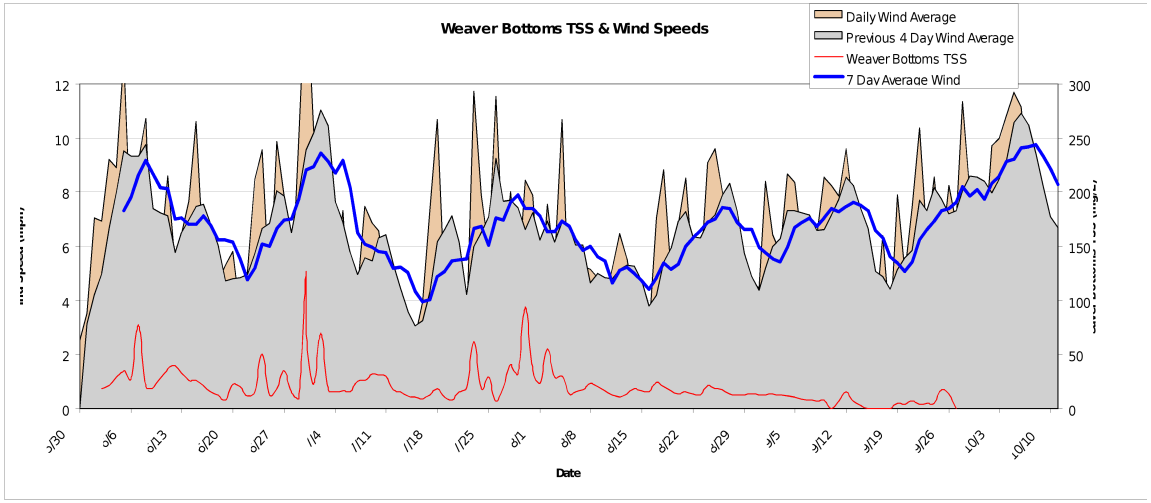
- **Hydraulic model** – describes physical environment

- **Habitat model** – describes use and function (*niche)*

- **Population model** – describes biological response

Monitoring

- Flow and Sediment Transport Regime
- Geomorphic Conditions
- Water Quality
- Plant Community Distribution & Species Richness
- Set up a plan early if data is needed to begin planning



Ecosystem Outputs

- Benefits ≈ ecosystem outputs
- Outputs consider quantity and quality

- Habitat Evaluation Procedures are accounting frameworks that are commonly used

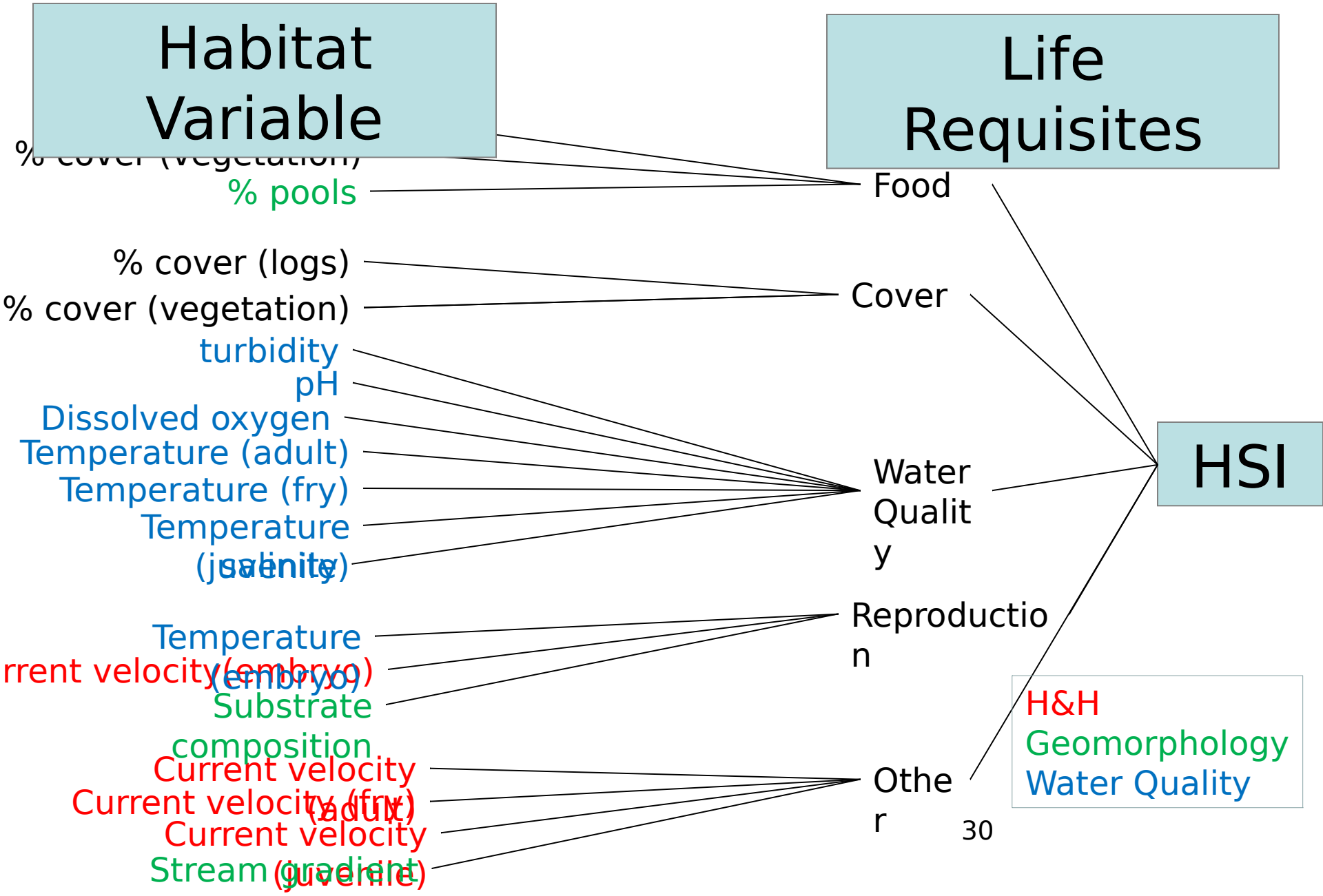
History of HEP (Habitat Evaluation Procedures)

Developed by US Fish and Wildlife Service

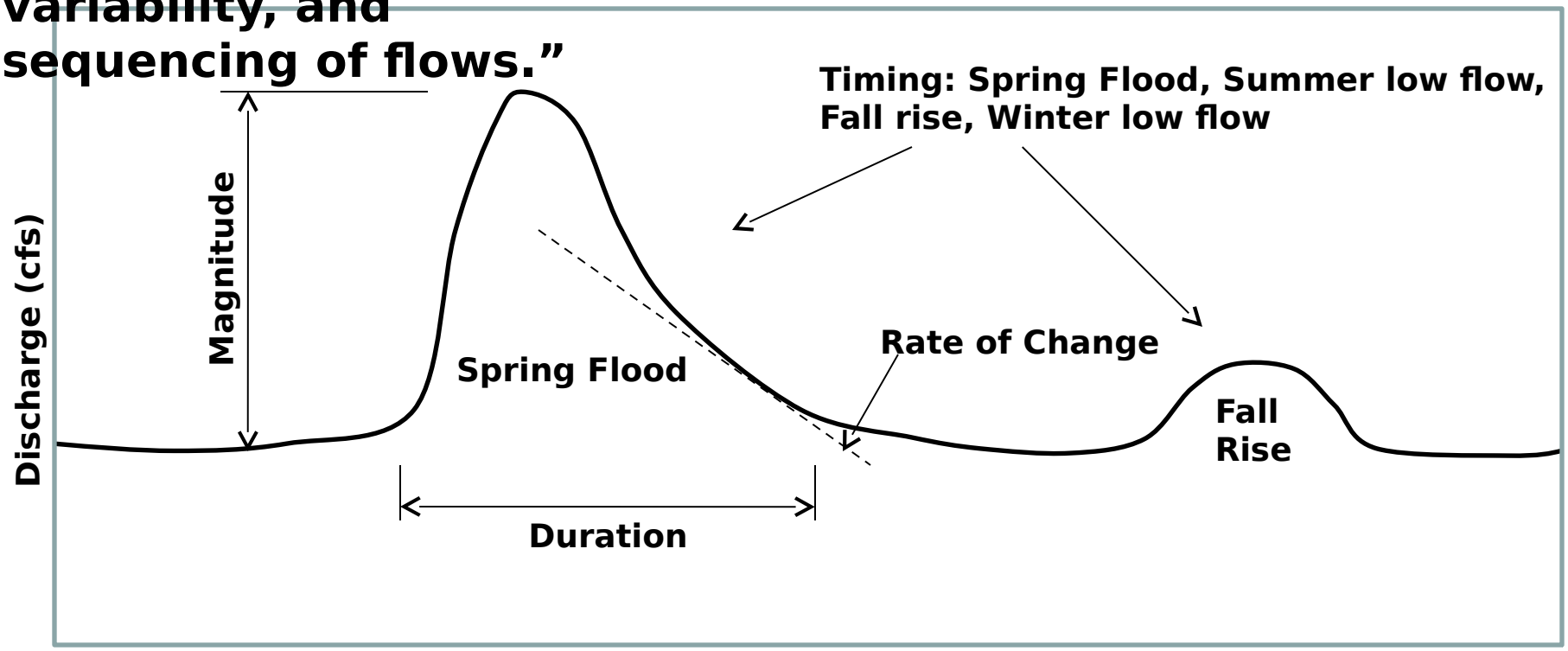
USFWS Ecological Services Manuals

- ESM 101 – Habitat as Basis for Environmental Assessment
- ESM 102 – Habitat Evaluation Procedures
- ESM 103 Standards for the Development of Habitat Suitability Index Models for use in HEP
  - http://www.fws.gov/policy/ESM101.pdf
  - http://www.fws.gov/policy/ESM102.pdf
  - http://www.fws.gov/policy/ESM103.pdf

Bluegill Model - Riverine



“Ecologically relevant components of stream flow include the flow magnitude, flow frequency, flow duration, timing of particular flow components, rate of flow change, inter-annual variability, and sequencing of flows.”



an April July Oct

A combination of H&H and biota monitoring were used to develop the conceptual models describing the relationship between seasonal hydrology and Cottonwood germination (left plot) or Interior Least Tern nest establishment (right plot).

From Oct, 2001 Stream Notes Published by the Rocky Mountain Research Center

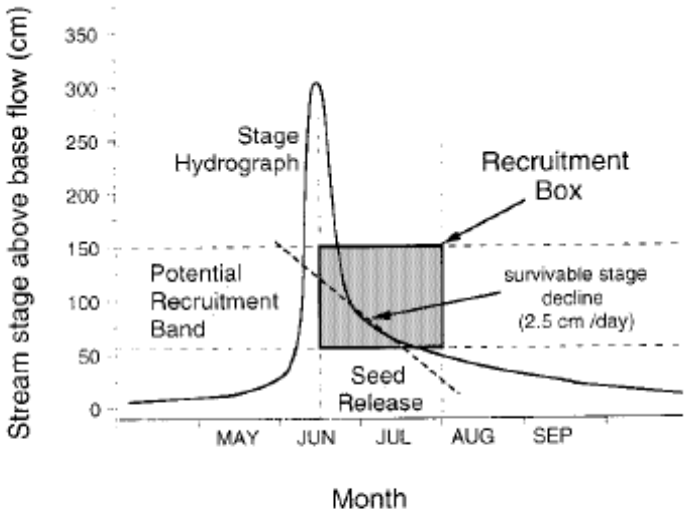
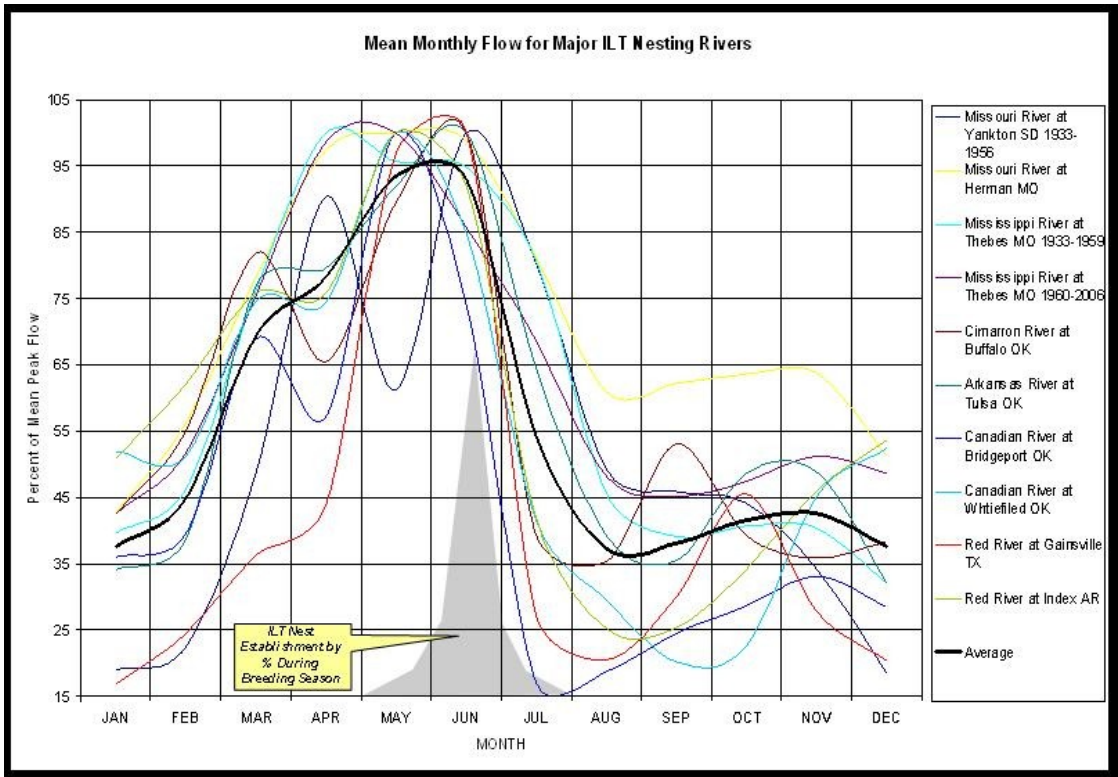


Figure 1. Parameters of the cottonwood seedling recruitment box model applied to the Bow River, Alberta (Mahoney and Rood, 1998; Wetlands (18): 634-645).

Missouri River Emergent Sandbar Habitat PEIS, Appendix B, Ch. 5 Interior Least Tern Nesting

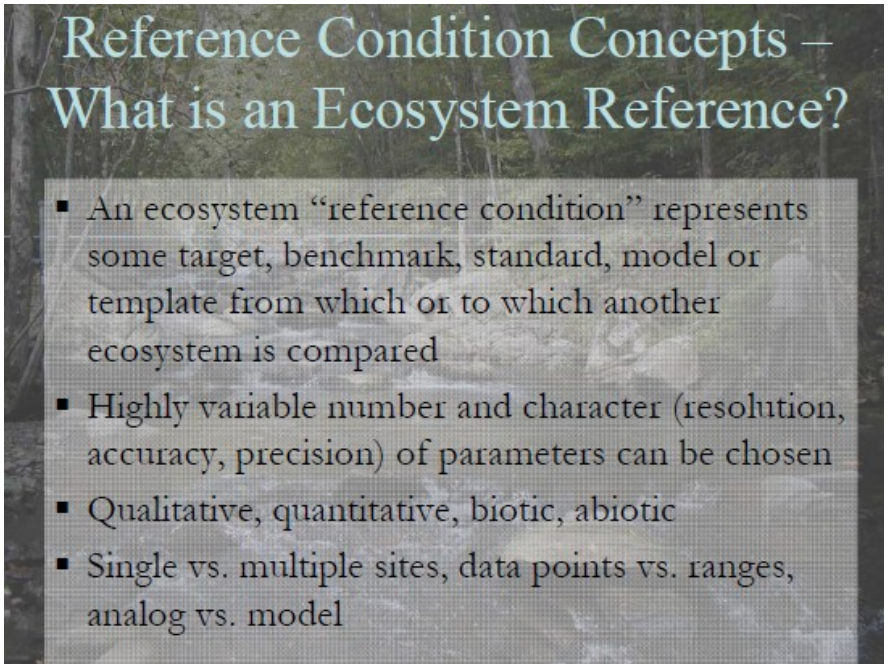


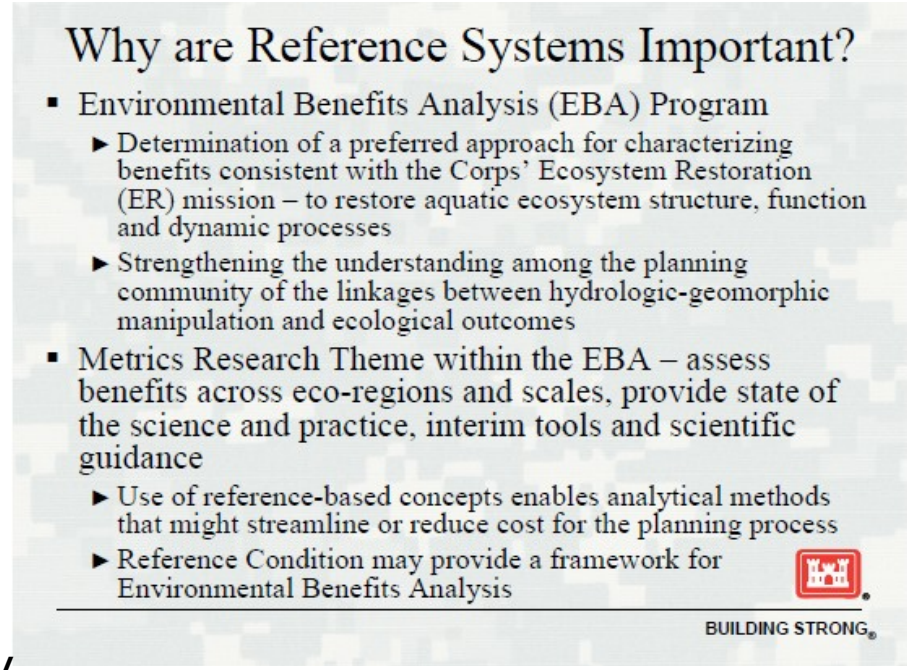
Connectivity

“Habitat such as riparian stream corridors provide connectivity between the extensive parkland and stream valleys, and provide wildlife corridors.” September 2009 Draft Anacostia Watershed Restoration Plan and Report (Baltimore District).

Hydrologic Connectivity: Water mediated transport of matter, energy, or organisms within or between elements of the hydrologic cycle (Jackson and Pringle, 2010, BioScience)

From Webinar on Reference Systems in Environmental Benefits Analysis, Sara J Miller, Research Ecologist, Fluvial Geomorpholist, ERDC, December 8, 2009


Reference Condition Concepts – What is an Ecosystem Reference?
An ecosystem "reference condition" represents some target, benchmark, standard, model or template from which or to which another ecosystem is compared
Highly variable number and character (resolution, accuracy, precision) of parameters can be chosen
Qualitative, quantitative, biotic, abiotic
Single vs. multiple sites, data points vs. ranges, analog vs. model


Why are Reference Systems Important?
Environmental Benefits Analysis (EBA) Program
Determination of a preferred approach for characterizing benefits consistent with the Corps' Ecosystem Restoration (ER) mission – to restore aquatic ecosystem structure, function and dynamic processes
Strengthening the understanding among the planning community of the linkages between hydrologic-geomorphic manipulation and ecological outcomes
Metrics Research Theme within the EBA – assess benefits across eco-regions and scales, provide state of the science and practice, interim tools and scientific guidance
Use of reference-based concepts enables analytical methods that might streamline or reduce cost for the planning process
Reference Condition may provide a framework for Environmental Benefits Analysis
BUILDING STRONG

Civil Works Environment Gateway

http://cw-environment.usace.army.mil/learning.cfm?CoP=Env

1930 Reference Conditions, Reno Bottoms

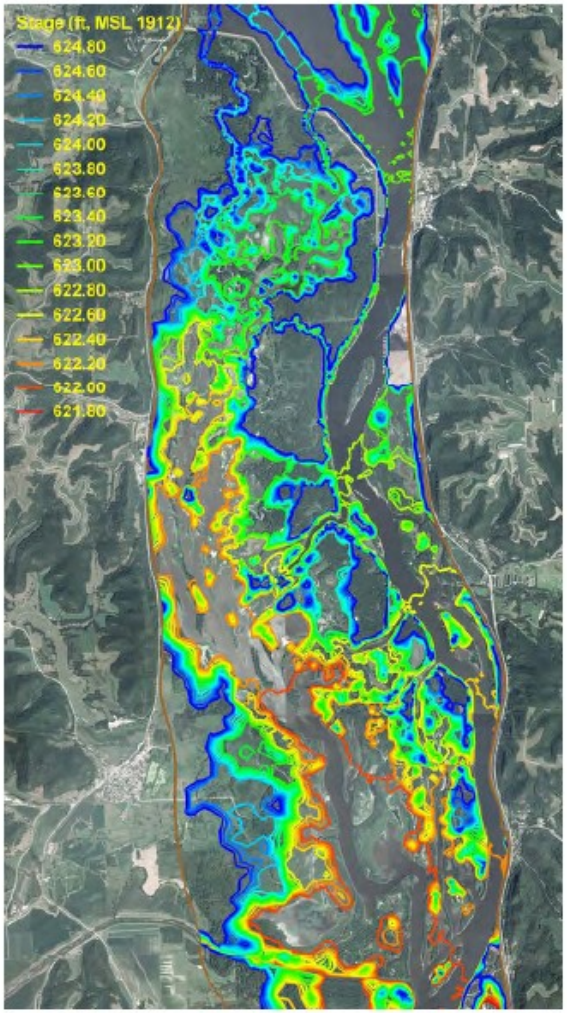
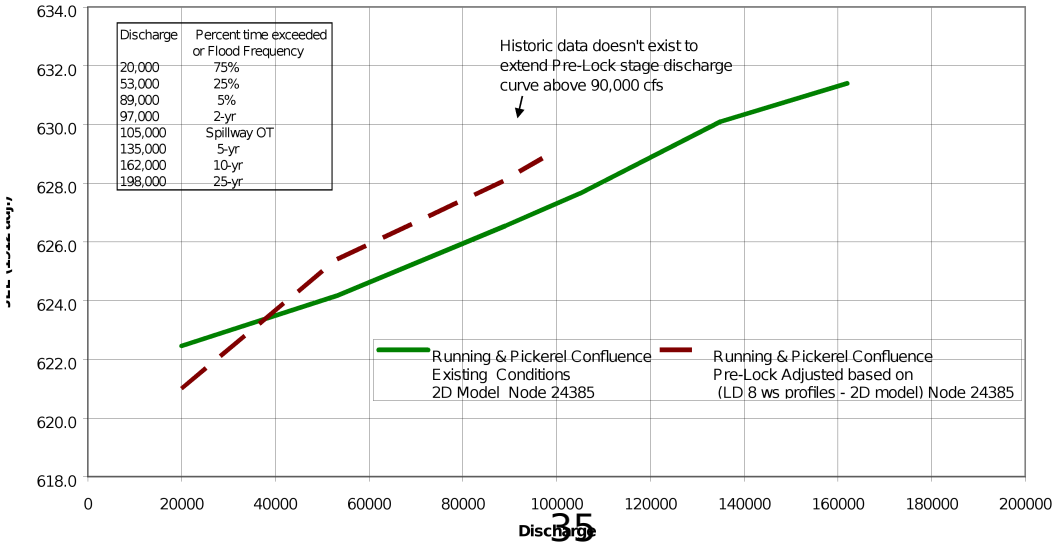


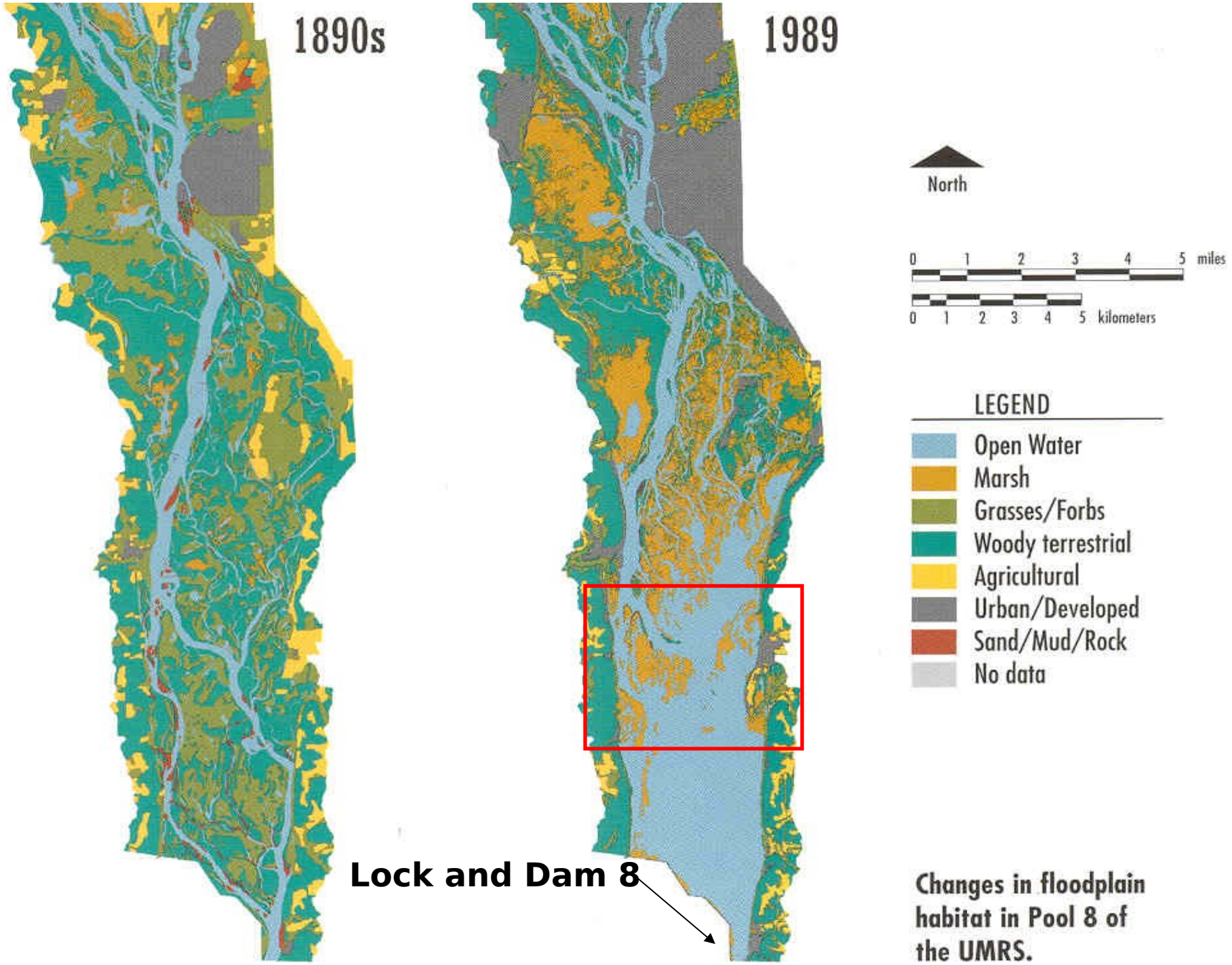
Plate 14: 1930 Reference Condition Stage Data for Total River Discharge of 32,000 cfs

Stage Discharge Relationships, Reno Bottoms (Running & Pickerel Slough Confluence)



Pool 8 Islands, Phase II, Upper Mississippi River, La Crosse, Wisconsin

pper Mississippi River
nvironmental Management Program



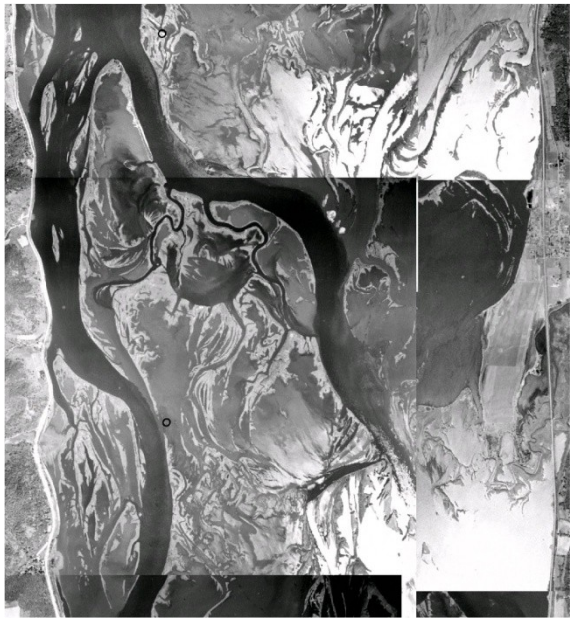
Changes in floodplain habitat in Pool 8 of the UMRS.

blems:
owing Lock and Dam 8 construction in 1937, many islands eroded
ny completely, or were reduced to small remnants as shown in this photo. In the
als below, the loss of islands is readily apparent.

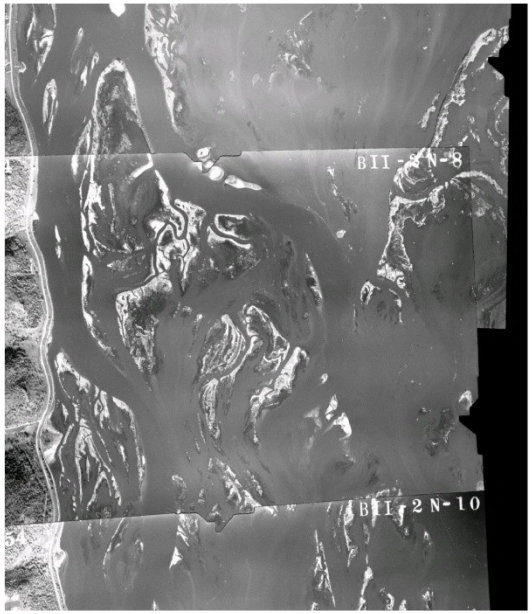
s resulted in:

- **Island Habitat Loss**
- **Altered Sediment Transport**
- **Increased Wind Fetch**
- **Increased Connectivity**
- **Altered Aquatic Habitat**

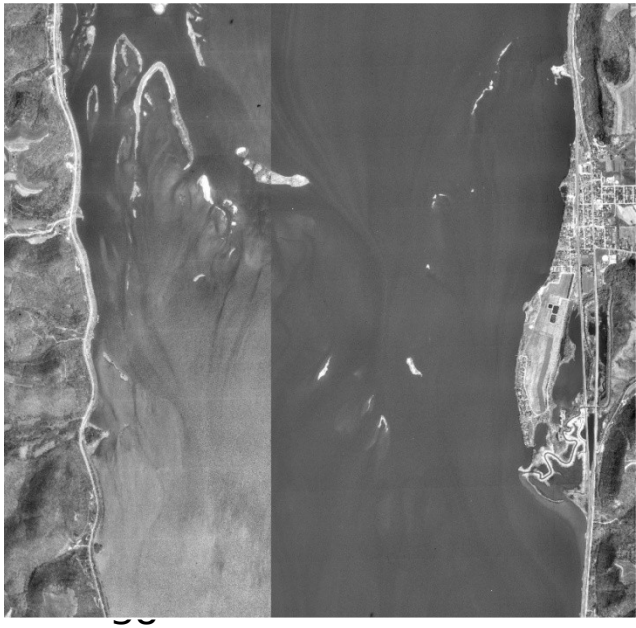
1938



1954



1991



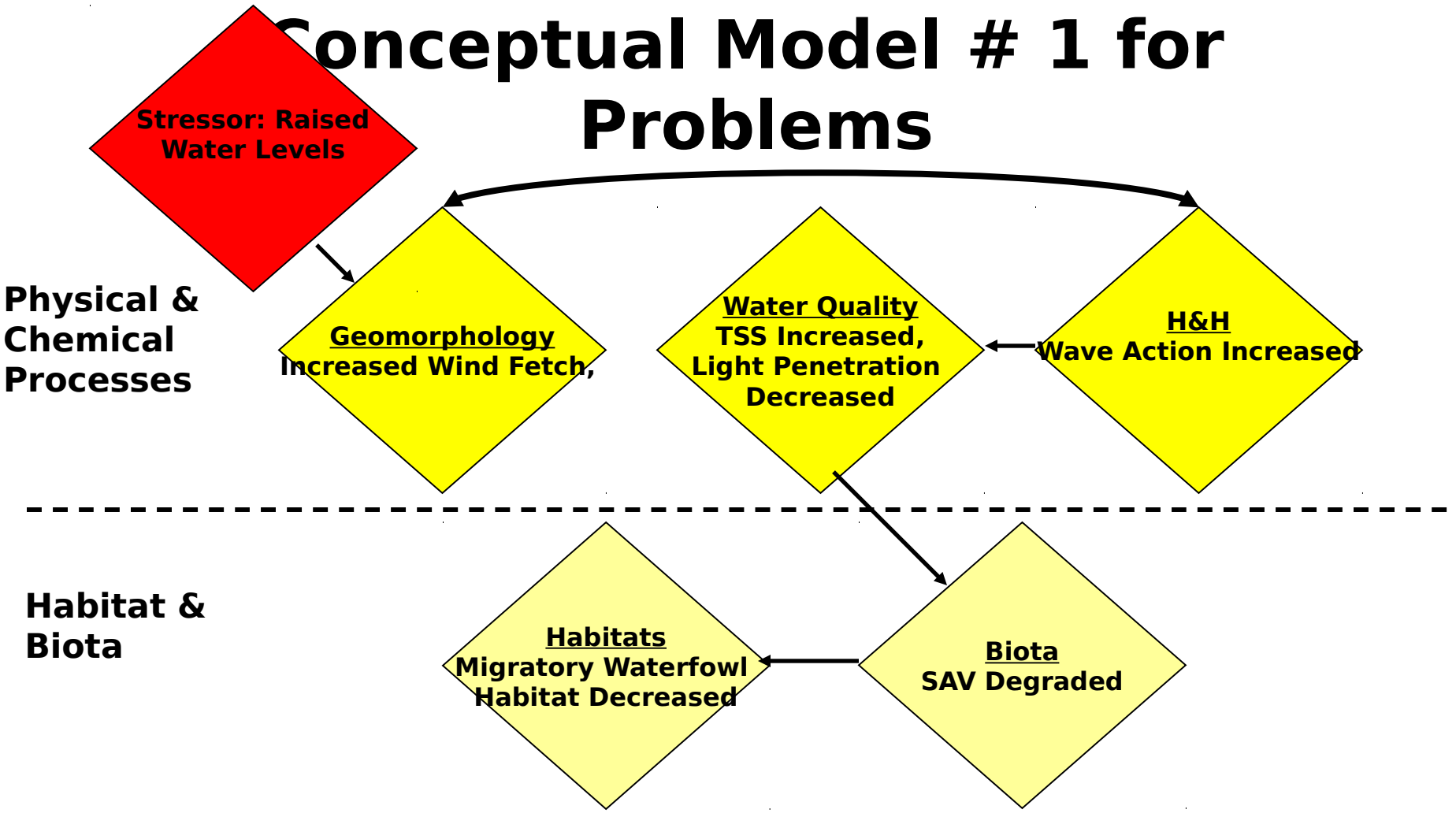
Upper Mississippi River Environmental Management Program

H&H Communication

- In-house Planning Team
  - Project Manager
  - Geotechnical for design and bank stability
  - Biologists for developing HEP model and criteria
  - Design engineering – Layout, quantities
- Beyond the In-house Planning Team
  - Local sponsor (USFWS)
    - O&M, Project Function, Refuge Compatibility
  - Wisconsin and Minnesota DNR Biologists–
    - Provided criteria for over-wintering fish habitat
    - Water quality permits
    - Floodplain Regulation
- Public
  - Public meetings
  - Provided insights on

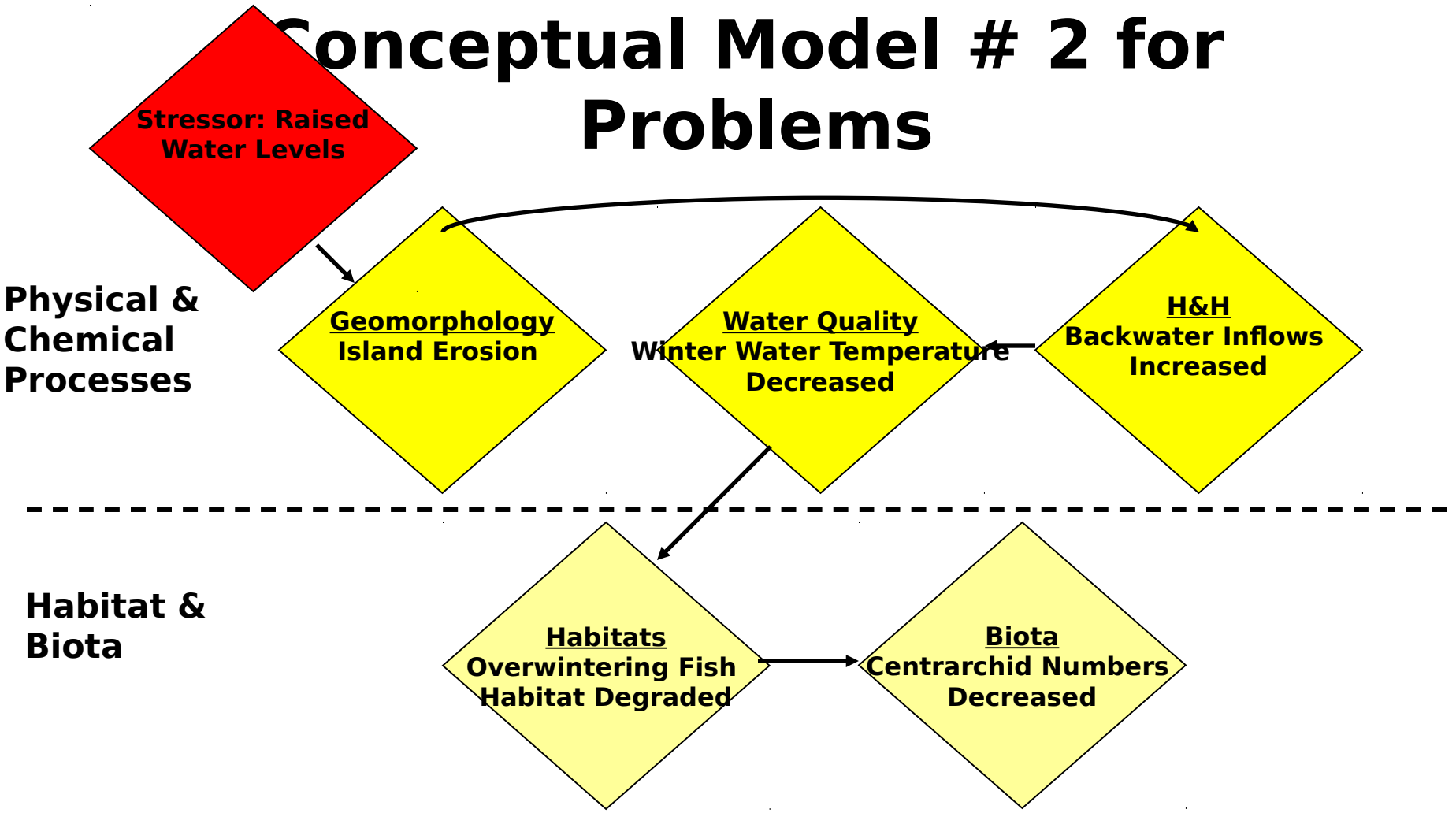
Environmental Management Program
Habitat Rehabilitation and Enhancement Project
What the heck is going on here?
We are enhancing habitat for waterfowl, fish and other aquatic animals in the Spring Lake area of the Upper Mississippi River National Wildlife and Fish Refuge. The project includes dredging channels and constructing five islands.
How are changes being made?
Most of the dredging is being done with the hydraulic dredge Iowa. The dredged material is pumped through the pipe and used to build the islands. Rock, barged in and placed with a hydraulic excavator, will protect the islands from erosion. All this should be completed by Fall 2005.
This construction project and the Pool 5 drawdown will complement each other to improve the fish and wildlife habitat in Spring Lake.
What happened?
Historically Spring Lake was a smorgasbord of plants and an excellent fishing hole. Over time, the higher water level created by Lock and Dam 5 uprooted the plants and eroded the islands. Channels and deep holes filled in with sediment and the wind and wave action kept sediment suspended. Spring Lake was slowly dying as a valuable area for fish and wildlife.
Environmental Management Program (EMP) is a US Army Corps of Engineers Program
Project Partners including you, the Public!
Spring Lake Islands

Lower Pool 8 Conceptual Model # 1 for Problems



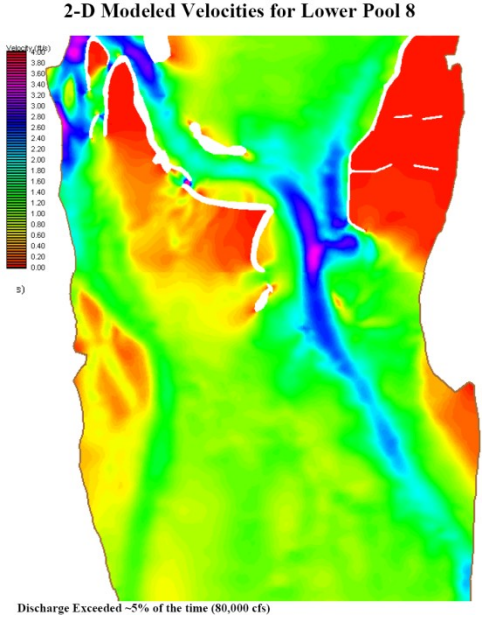
Important H&H variables: wind-driven wave action

Lower Pool 8 Conceptual Model # 2 for Problems



Important H&H variables: Backwater inflows and current veloci

- Monitoring needs
  - Hydrodynamic:
    - Flow distribution, velocities, water surface: open water and winter
  - Geomorphology:
    - Bathymetry in channels and backwaters
    - Aerial photos for geomorphic changes
  - Water Quality:
    - Winter dissolved oxygen, temperatures
  - Vegetation:
    - SAV aerial extent and composition
  - Biota (Ecological Response)
    - Backwater fish CPUE

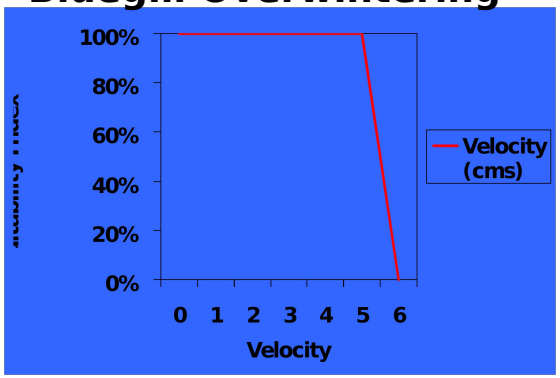


- Model needs
  - H&H:
    - 2-D model was used to simulate flows varying from low flow to the 100-year flood.
    - Wind-driven wave action from SPM (Coastal Engineering Manual
  - Geomorphology:
    - Sediment Transport: Compared bathymetry from two time periods to ID erosion/deposition patterns. Expert Opinion
  - Water Quality:
    - H&H results were used to interpret WQ conditions
  - Vegetation: None
  - Biota (Ecological Response)
    - HEP for Bluegills

Predictive

Comparative

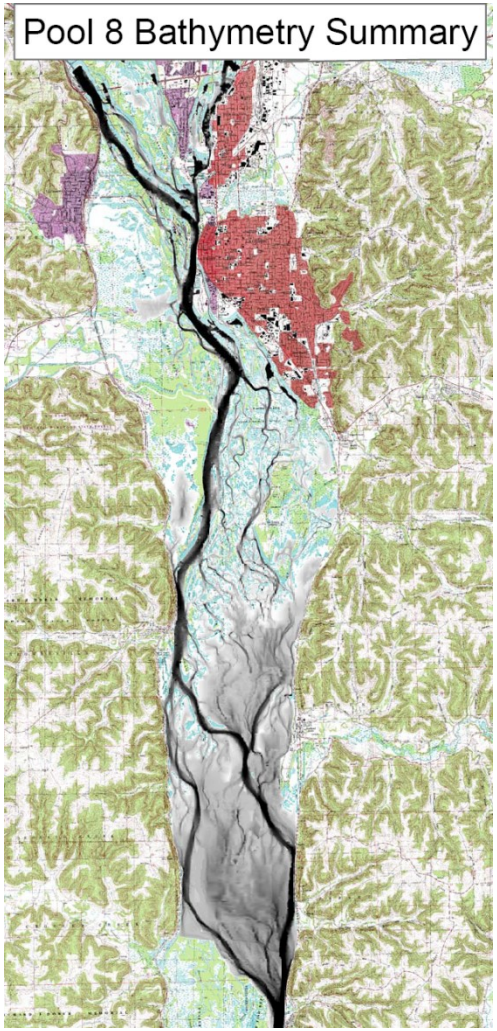
Bluegill Overwintering



Planning Step:
Inventory Existing Conditions

Data needs:
- **Topography**
- **Flow distribution**
- **Vegetation cover**
- **Aquatic areas**
- **Fish and Wildlife**

Model needs:
- **2D models**
- **Wind fetch**
- **Vegetation Succession**



Planning Step: Future Without-Project Conditions

Data needs:

- **Existing conditions inventory**
- **Aerial photo analysis**
- **Substrate**

Model needs:

- **2D model hydraulic (RMA-2V)**
- **Geomorphic Change (interpreted from 2D model)**

Vegetation Succession (SAV) based on expert opinion

Bottom line is that a multi-agency team of river managers did not think lower pool 8

Planning Step:
Identify Project Objectives

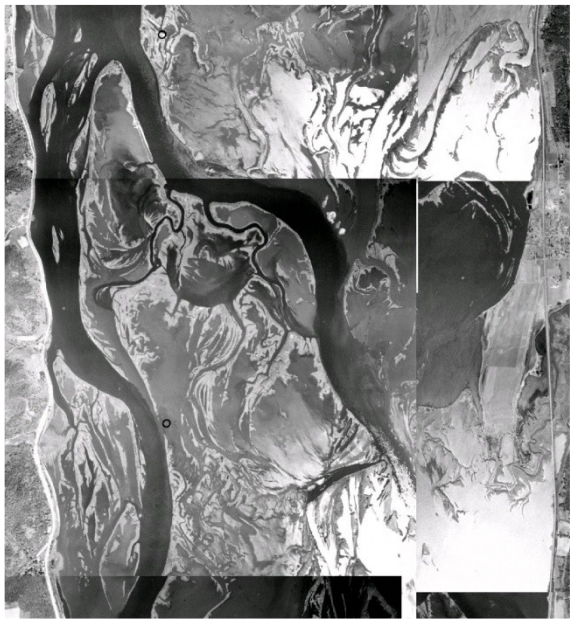
Objectives were developed for lentic fish, waterfowl migration habitat, and a number of other species.

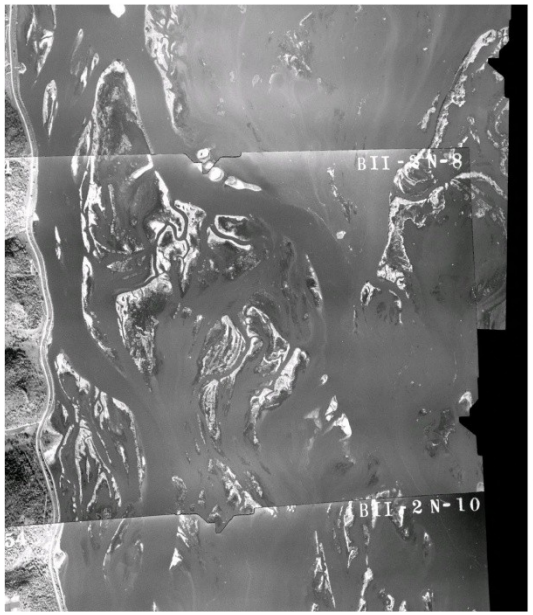
Criteria established links between H&H, geom., WQ, habitat & biota

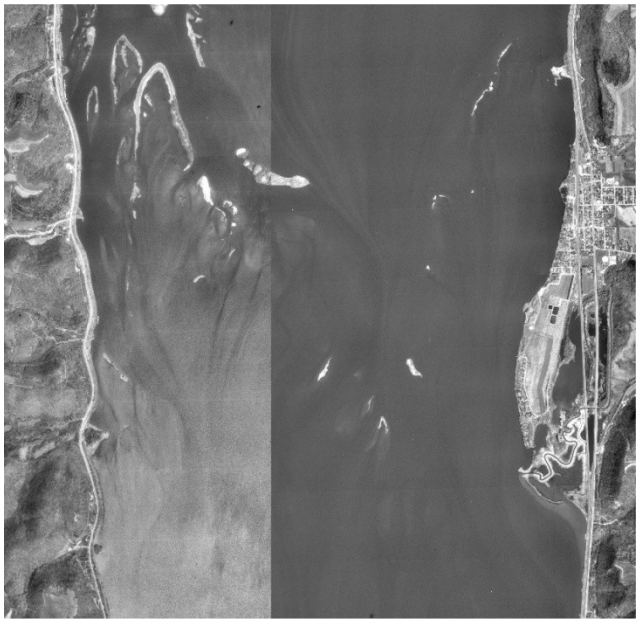
Data needs:

- **Information from existing conditions inventory**
- **Forecasted future without-project conditions**
- **Reference Conditions (Historic or Virtual)**

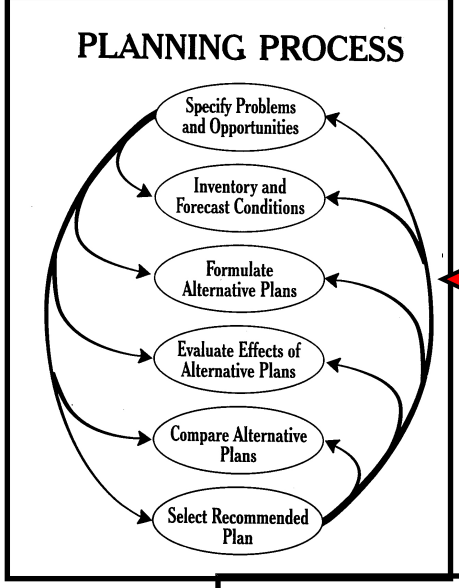
1938 **1954** **1991**





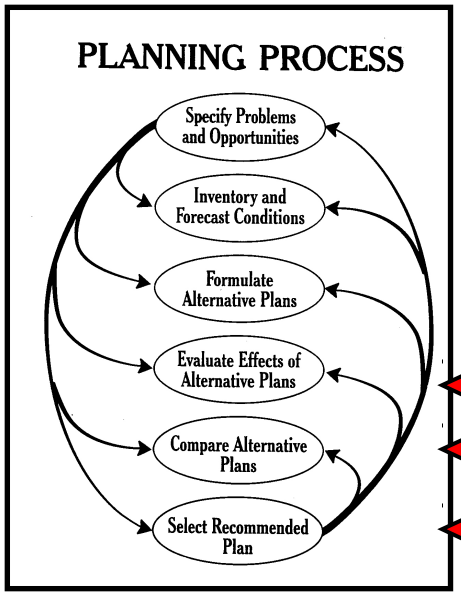


Phase II Goals	Objectives	Performance Criteria
Improve habitat conditions for backwater fish species with an emphasis on habitat for Centrarchids.	Create 200 acres of overwintering habitat meeting the following criteria:	a) Dissolved oxygen levels > 3 mg/l b) Current velocity < 0.3 cm/sec over 80% of the area. c) Water temperature as follows: □) 4□C over 35% of the area, □) 2-4□C over 30% of the area, □) 0-2□C over 35% of the area. a) Water depths > 4 feet over 40% of the wintering area in year 25.
	Enhance and/or create Centrarchid summer habitat meeting the following criteria:	a) Dissolved oxygen levels > 5 mg/l. b) Aquatic vegetation cover in the range of 25-50%.
	Enhance and/or create spawning, rearing, and juvenile Centrarchid habitat in three locations, each approximately 5 acres in size, meeting the following criteria:	a) Dissolved oxygen levels > 5 mg/l. b) Current velocity < 0.5 cm/sec. c) Aquatic vegetation cover of approximately 80%. d) Substrates of sand and/or gravel available for spawning.
Increase high quality waterfowl habitat to 600acres and then maintain.	Increase and than maintain 600 acres of habitat meeting the following criteria:	a) Aquatic plant growth covering approximately 60% of the area with a mix and interspersion similar to conditions that existed in 1975. b) Create 2 to 3 acres of nesting habitat isolated (0.5 mile) from land based predators and with a vegetative cover having an average obscurity rating of 1.5 dm within 2 years. c) Protected sites (i.e., beaches, mudflats, and logs) for birds to get out of the water to loaf and rest totaling approximately 6 acres.



Formulate Alternative Plans

Factor considered	Design Considerations
River Function	Island Layout: reduce backwater flow, increase channel flow, reduce wave action. Minimize elevation to maintain flood flow
Habitat	Aquatic: Maximize sheltered area meeting criteria. Terrestrial: Provide Elev. & width variation
Shoreline Stability	Island Position, shoreline stabilization & topsoil
Flood Impacts	Minimize island elevations
Constructability	Higher elevations & greater width improve equipment operation
Cost	Access (good to poor). Minimize elevations & width



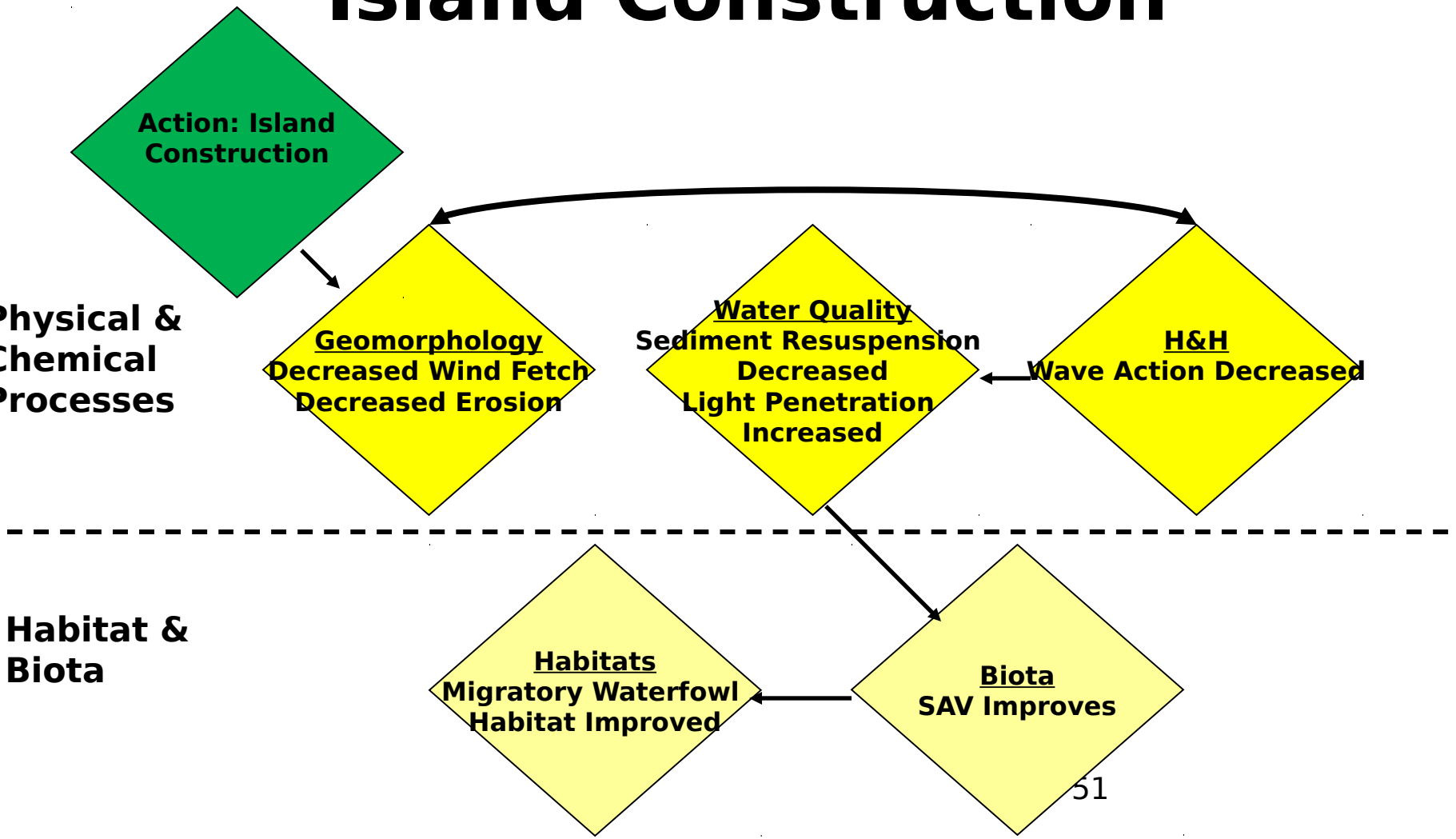
Evaluate Effects of Alternative Plans
Compare Alternative Plans
Select Recommended Plan

- **Cost for each alternative**
  - **Island layout, elevations, widths, side slopes, and material**
  - **Shoreline stabilization option range from biotechnical to revetments**

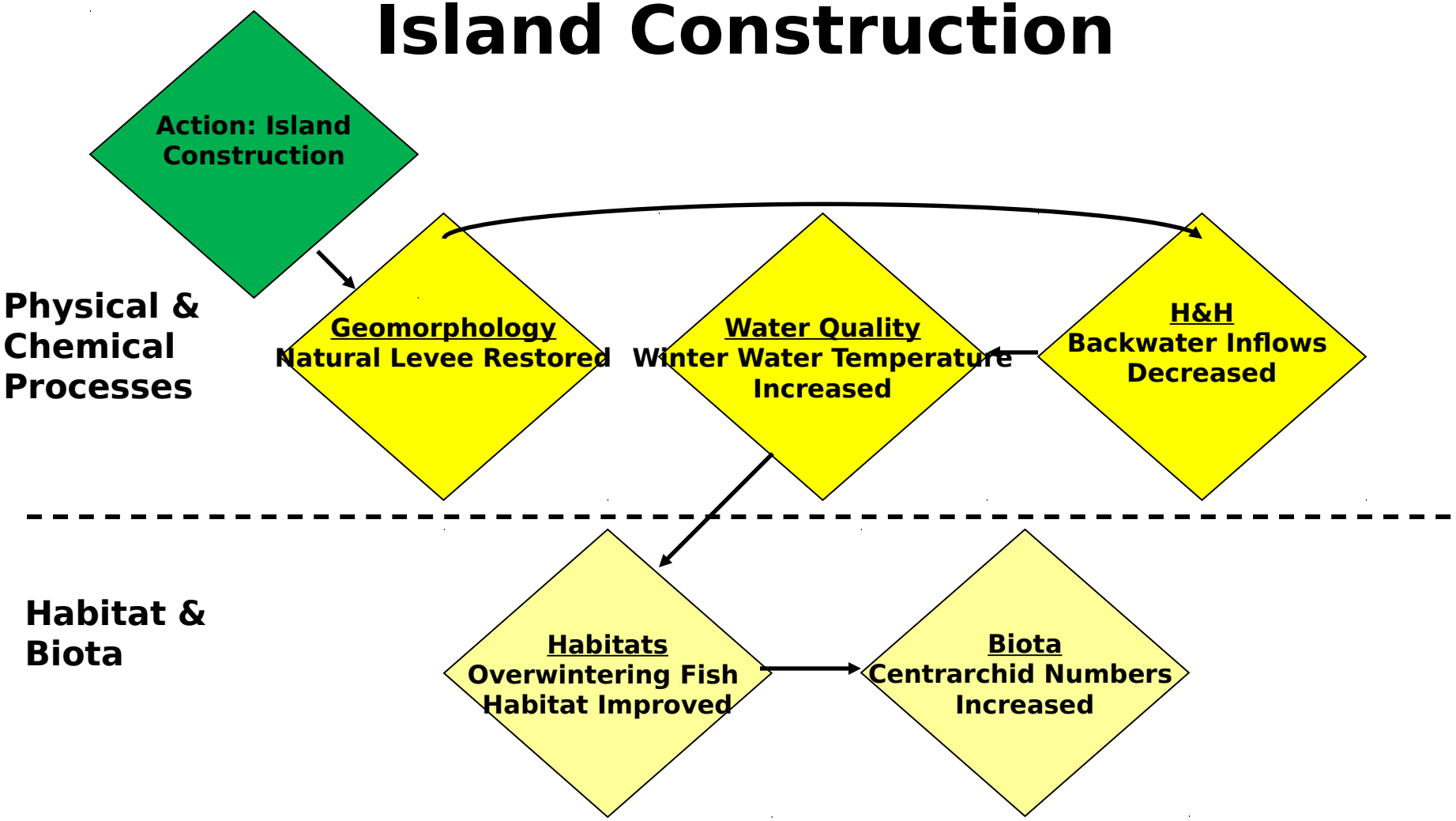
- **Ecological Outputs**
  - **A HEP model for bluegills was used to assess the outputs of each alternative.**
  - **SAV response was based on expert opinion**

- **H&H Needs for Ecological Outputs**
  - **The 2-dimensional hydraulic model was used to simulate velocities throughout the area.**
  - **Wave action analyzed based on SPM deep-water wave equations**
  - **These results along with expert input on water quality (D.O. and temperature) effects were used in the HEP model for bluegills.**
  - **Sediment transport was interpreted based on**

Lower Pool 8 Conceptual Model # 1 for Island Construction

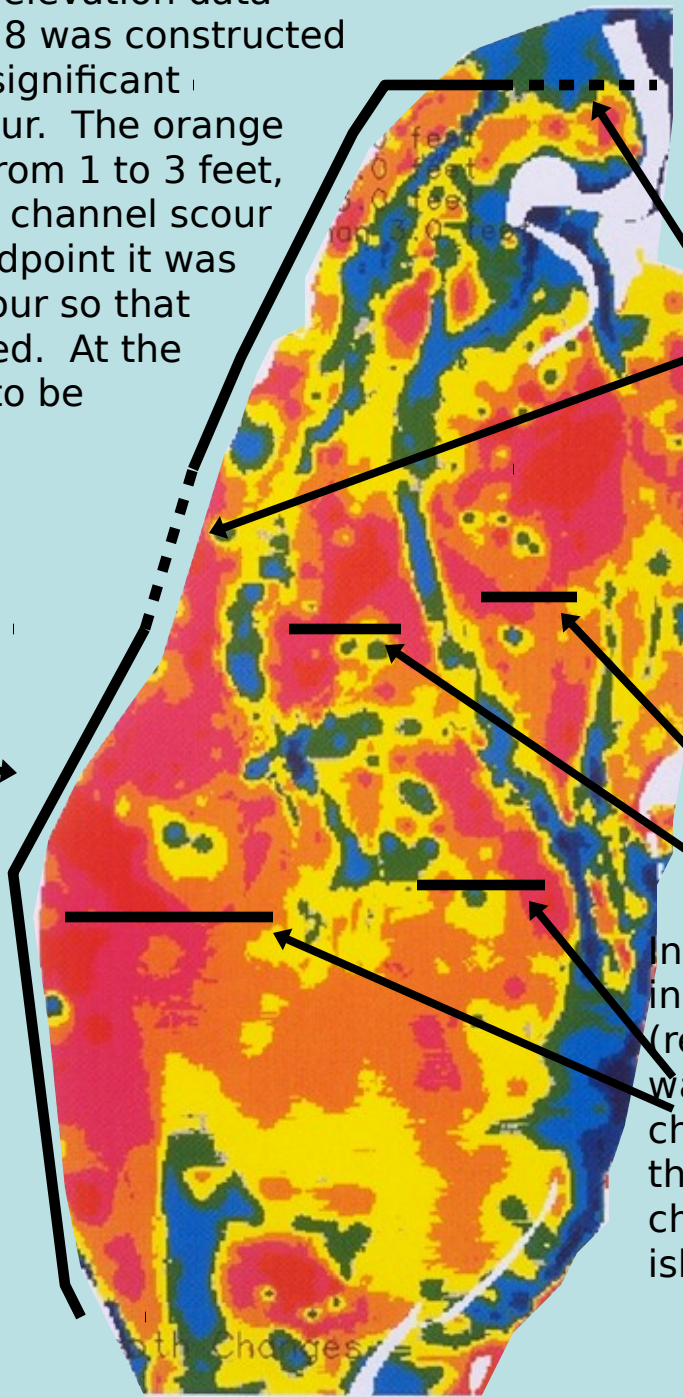


Lower Pool 8 Conceptual Model # 2 for Island Construction



n the Phase II Area, a comparison of elevation data rom the 1930's when Lock and Dam 8 was constructed o elevations in the 1990s indicated significant ediment deposition and channel scour. The orange nd red colors represent deposition from 1 to 3 feet, hile the greens and blues represent channel scour rom 1 to 3 feet. From a habitat standpoint it was esirable to maintain the channel scour so that eep water habitat would be sustained. At the ame time sediment deposition had to be educed to preserve aquatic habitat

Phase II Area Design



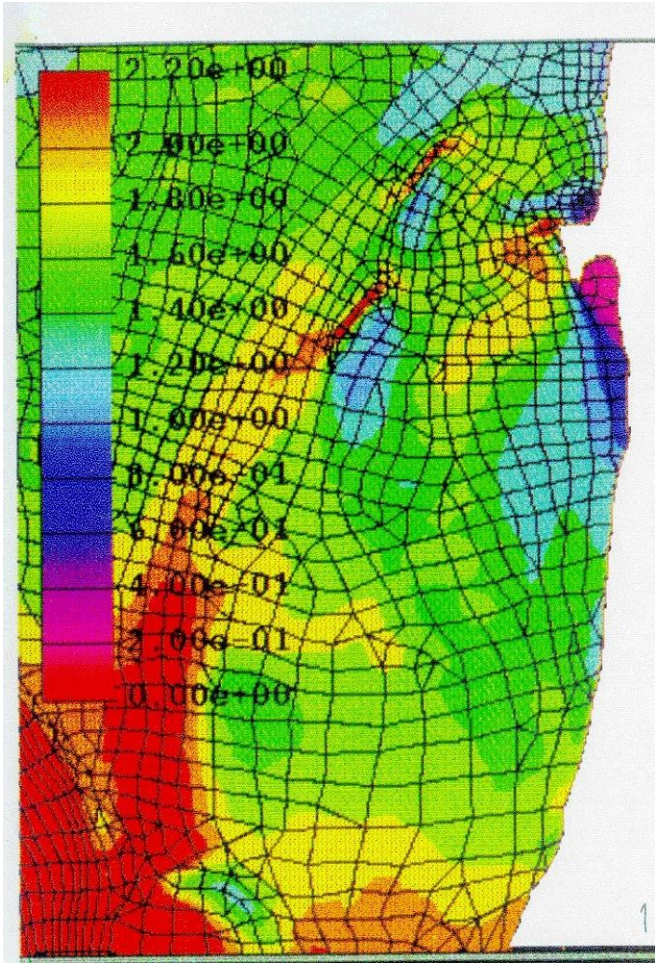
Rock sills were constructed in two places along the Phase II Area periphery to allow floodplain conveyance during floods

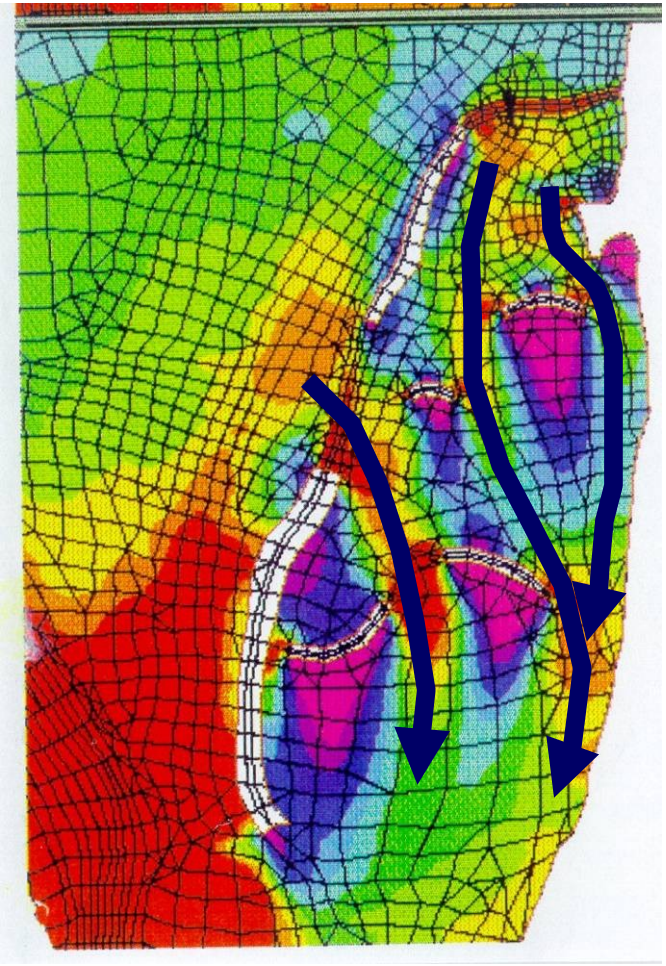
The design team determined that large barrier islands were needed along the periphery of the Phase II area to reduce sediment inflow, reduce velocities, and restore natural floodplain conditions.

Interior Islands were positioned in sediment deposition areas (red & orange color) to force water to flow through the channels (blue and green color) that had formed promoting channel scour. These interior islands also reduce wave action

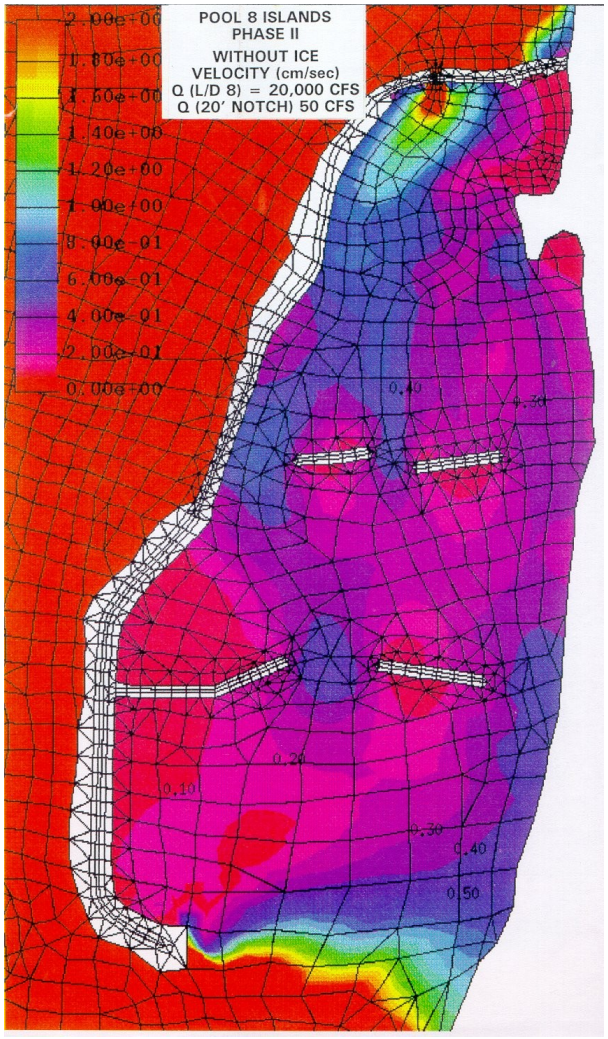
Pool 8 Islands Phase II
10 Year Flood Conditions

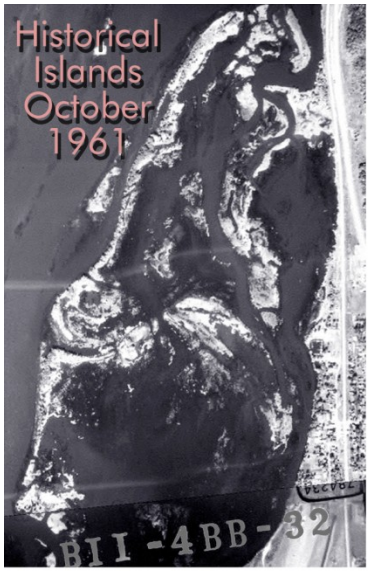
Velocity (ft/sec) Q(L/D 8) = 161,000

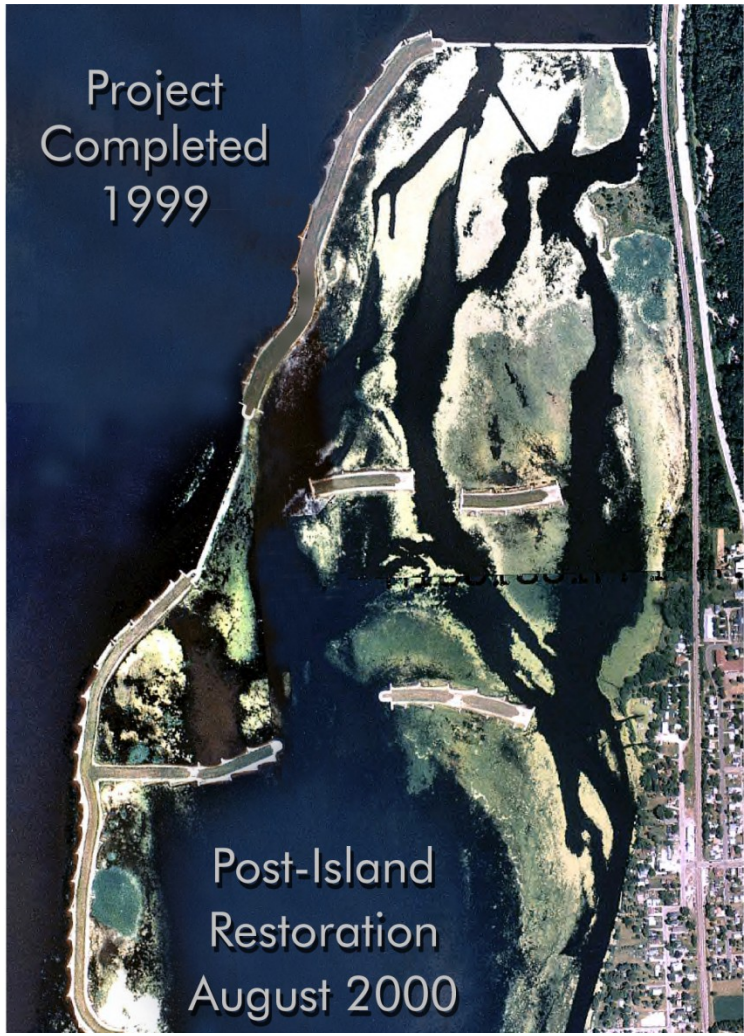




Planning Steps: Formulate, Evaluate, Select Alternative Plans

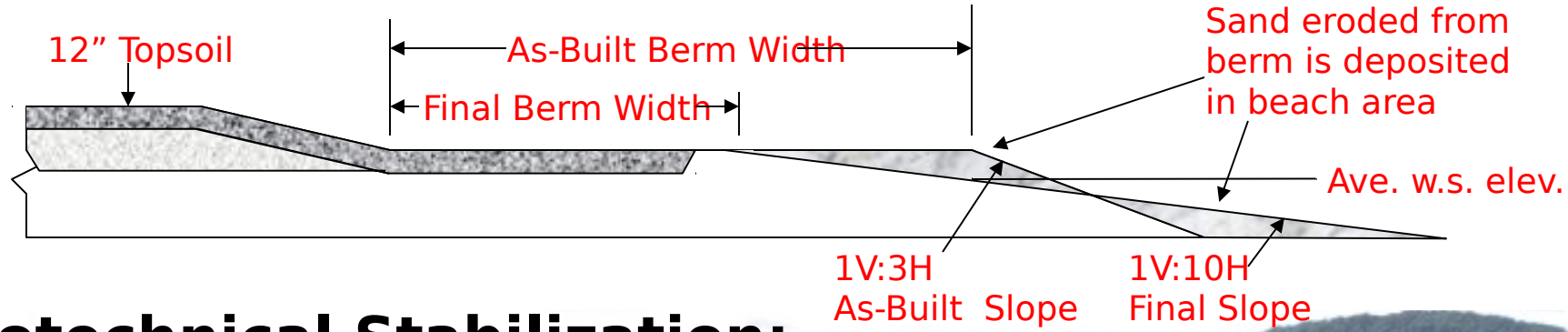






Island Construction

Flow Distribution, Wind Fetch, Floodplain Elevation



Biotechnical Stabilization:

Berms, Willows, & Groins

Two rows of Willow Plantings

Rock Groin

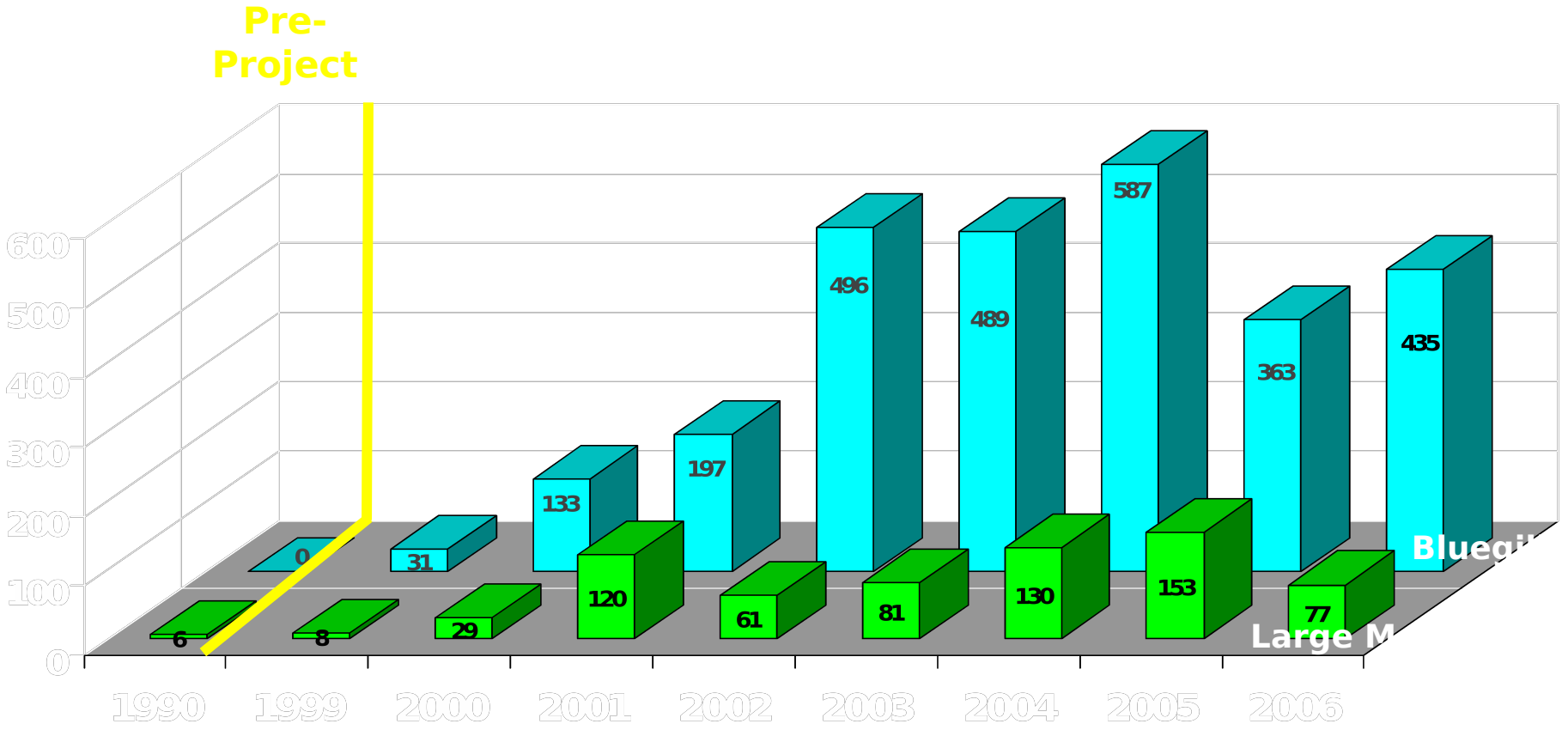
Sand Berm

Fine Sediments for Topsoil

The 1993 flood overtopping Boomerang Island
Inset photograph – damage to turtle nesting mound on Slingshot Island

Pool 8 Islands Phase II

Pre- and Post-Project Fall Electro-fishing



Phase I
Barrier Islands restore natural channel/floodplain flow regimes
Phase III
Shoreline stabilization protects existing islands
Seed Islands
eed Islands increase bathymetric diversity by promoting sediment deposition downstream of the islands and sediment erosion on either side of the islands
The End
7/11/2001 10:23am

H&H in Planning Summary

Study →	Pool 8 Islands, WI	Rio Salado, AZ	RRN Fish Passage, ND	Pekin Lake, IL
H&H Parameters	Q (flow patterns), v (velocity) F (wind fetch)	Q(volumes), Water levels Groundwater	v	Water levels
Objectives	Waterfowl and Fish Habitat Other species	Riparian Habitat	Fish Migration	Moist Soil Habitat
H&H Monitoring	Q, v, Water levels	Water levels Groundwater	Water levels bank erosion	Water levels
H&H modeling	ADH - 2D model	HEC-RAS HEC-6T	HEC-RAS 3D model, ERDC	HEC-RAS
H&H constraints	FP regulations	FP regulations Groundwater	FP regulations u/s water levels	FP regulations

H&H in Planning Summary

Study	Anacostia Watershed, Wash D.C.	Ventura Marsh, IA	Missouri River ESH, SD	Southwest Florida
H&H Parameters	Q (stormwater) Nutrients TSS	Water levels	Q (volume) Water levels	Q (volume, timing) Salinity Nutrients
Objectives	Reduce Pollutants Fish Passage Wetlands	Aquatic Habitat	ESH for ILT and PP	Q to Estuaries Hab. Connectivity Salinity Nitrogen loads
H&H Monitoring	Q Impervious Surfaces	Water levels	Water levels bank erosion	Water levels
H&H modeling	WTM: Spreadsheet model GIS	Water Budget	HEC-RAS GIS	HEC-RAS Stella GIS
H&H constraints	FP regulations		FP regulations	FP regulations